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SUGARBEET RESEARCH

1970 REPORT

COMPILED BY

SUGARBEET INVESTIGATIONS

PLANT SCIENCE RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

A Report to and for
the Sole Use of Cooperators

NOT FOR PUBLICATION

F O R E W O R D

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The report presents results of investigations strengthened by contributions received under Cooperative Agreements between Plant Science Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers and Manufacturers Beet Sugar Association; Union Sugar Division, Consolidated Foods Corporation; the California Beet Growers Association, Ltd.; and the Red River Valley Sugarbeet Growers Association, Inc.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture or the Beet Sugar Development Foundation.

CONTENTS

	Page
SECTION A GENERAL REPORT	
New developments in breeding research	A1
Utilization of USDA seed releases	A6
Abstracts of papers approved for publication . . .	A9
SECTION B SALINAS AND BRAWLEY, CALIFORNIA	
Summary of accomplishments, 1970	B2
Development of varieties and breeding lines for California	B6
Breeding for nematode resistance	B35
Nematology investigations	B49
Interspecific hybridization	B64
Virus investigations	B69
Evaluation of curly top virus field inoculations on sugarbeet	B71
Effects of fumigation, fertilizer, variety and crop rotation on yield, sucrose and purity of sugarbeets	B74
SECTION C LOGAN, UTAH	
Summary of research accomplishments, 1970	C2
Variety tests, Logan and Farmington, Utah, 1970. .	C6
Variety trials for curly top resistance	C41
Studies on the variation of partial-male fertility	C44
Virus investigations	C50
Respiration rates of several sugarbeet varieties	C54
Evaluation of wax coatings for sugarbeet storage	C55

CONTENTS

	Page
SECTION D FORT COLLINS, COLORADO	
Summary of accomplishments, 1970	D3
Rhizoctonia resistance breeding investigations, 1970	D10
Inheritance of Rhizoctonia resistance in sugarbeet	D11
Rhizoctonia resistance evaluation of contributed sugarbeet varieties	D17
Rhizoctonia resistance evaluation of miscellaneous sugarbeet lines and hybrids	D20
Effect of selection for Rhizoctonia resistance on the means and variances of root yield and sucrose	D22
Summary of comparisons of Rhizoctonia- like isolates from sugarbeet	D26
Potential of Rhizoctonia isolates to incite damping off, foliar blight, and root rot in sugarbeet	D27
Longevity of Rhizoctonia isolates under cold storage	D29
Development and evaluation of sugarbeet breeding material and varieties with resistance to both leaf spot and curly top, 1970	D30
Variability of single-spore isolates of <u>Cercospora beticola</u>	D51
Sugarbeet leaf amino acids and their role in Cercospora leaf spot resistance	D54
Thin juice amino acids and other quality characters in leaf spot infected and noninfected sugarbeets	D60
Studies on the inheritance of resistance to Cercospora leaf spot	D67

CONTENTS

	Page
Diallel analyses of sugarbeet characters	D68
Studies on chemical induction of pollen sterility in sugarbeet	D68
Apomixis screening	D71
The use of mitochondrial complementation as a breeding tool	D71
Nitrogen inventory study of sugarbeet thin and pressed juice including percent of individual amino acids	D73
Sugarbeet leaf amino acids in different sections of the leaf and in different aged leaves	D81
SECTION E EAST LANSING, MICHIGAN; BELTSVILLE, MARYLAND; AND FARGO, NORTH DAKOTA	
Evaluation of sugarbeet hybrids	E2
Varietal resistance to Rhizoctonia	E16
Breeding sugarbeets for resistance to black root and leaf spot	E19
Seed production program for the eastern area . . .	E23
Powered auger used to dig holes for mother roots	E27
Sugarbeet disease investigations at East Lansing, Michigan in 1970	E28
Physiological investigations - 1970	E35
Physiological and histological investigations of sugarbeets	E39
Seedling diseases, Red River Valley	E55
Pectolytic enzyme production by sugarbeet storage rot organisms	E57
Red River Valley variety tests	E69

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase
May 13, 1970

Breeder seed and inbred lines that have been developed in the breeding research conducted by the staff of Sugarbeet Investigations are proposed for seed production through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new productions of breeding research have been developed by the staff of Sugarbeet Investigations in work conducted under Cooperative Agreements with:

California Agricultural Experiment Station
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.
California Beet Growers Association

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane,
R. T. Lewellen, and I. O. Skoyen:

Item 1. C910 Multigerm 50 grams

Second successive yellows resistant selection from cross 321 x 234. 321 (Item 3, 1964) is a yellows resistant selection from a self sterile, type 0 population. 234 (Item 5, 1966) is a self-sterile yellows resistant selection developed by the Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands. C910 has good bolting resistance and is segregating for curly top resistance, yellows resistance, and the type 0 character.

Suggested utilization: Use in a breeding program to develop self sterile, type 0, yellows resistant parent lines.

Item 2. C0705 Monogerm 1 pound

A yellows resistant, self fertile, type 0 line derived from a cross between 321 (Item 3, 1964) and 2743. 2743 was selected for yellows resistance from a cross between 928-20 and 9561 (Item 7, 1959). 928-20 is a yellows resistant selection from a line developed by the Instituut voor Rationele Suikerproductie, Bergen op Zoom, Netherlands. C0705 has shown the best yellows resistance of any monogerm line in our program. It possesses good bolting resistance, fair curly top resistance, and has shown good sucrose percentage. Plant type is still variable and opportunities exist for further selection.

Item 3. C0705H0 Monogerm 1 pound

CMS equivalent of 0705 produced from three backcrosses to 0705 type plants.

Suggested utilization: Source of yellows resistance and as components in experimental 3-way hybrids.

B. Developments in breeding and genetic research by V. F. and Helen Savitsky:

Item 4. S-5-692-2 Multigerm 2 pounds

Tetraploid self-sterile population of Polish origin, high in sucrose. Curly top susceptible.

Item 5. S-3-519 Multigerm 250 grams

Tetraploid self sterile population, high in curly top resistance. (Logan selection).

Item 6. S-4-563 Monogerm 250 grams

Tetraploid self sterile population, high in curly top resistance. (Logan selection).

Item 7. S-4-971 Multigerm 200 grams

Tetraploid self-sterile hybrid population between curly top resistant and leaf spot resistant strains.

Item 8. S-4-601 Multigerm 200 grams

Tetraploid self-sterile hybrid population between curly top resistant strain and tetraploid US 401 (LSR). Good in vigor.

Item 9. S-4-936 Multigerm 200 grams

Tetraploid self-fertile hybrid population between tetraploid US 401 (LSR) and high sucrose strain.

Item 10. S-4-929 Multigerm 150 grams

Similar to Item 9.

Item 11. S-4-908 Multigerm 150 grams

Tetraploid self-sterile hybrid population between curly top resistant and high sucrose strain.

Item 12. S-4-903 Multigerm 200 grams

Tetraploid self-sterile hybrid population between curly top resistant tetraploid 340 and high sucrose strain.

Item 13. S-5-537-5 Monogerm 200 grams

Tetraploid inbred line. Resistant to leaf spot.

II. Crops Research Laboratory, Colorado State University, Fort Collins, Colorado.

Developments in breeding research of J. O. Gaskill:

Item 14. FC 701/4 Multigerm 3 pounds

Rhizoctonia resistant; a reselection for Rhizoctonia resistance from FC 701/2 and a "sister" line, FC 701/3; about 3% rr; presumably self sterile; narrow base and probably rather low in root yield; total number of cycles of selection for Rhizoctonia resistance, 6; source, GW 674-56C (a LSR commercial variety); current seed no., SP 691246-00 (germination, approx. 91 s/g).

Suggested utilization: Increase; make experimental hybrids; use in breeding work as a source of genes for Rhizoctonia resistance.

Item 15. FC 702/4 Multigerm 4 pounds

Rhizoctonia resistant; a reselection for Rhizoctonia resistance from FC 702/2 and a "sister" line, FC 702/3; about 46% rr; presumably self sterile; narrow base and probably rather low in root yield; total number of cycles of selection for Rhizoctonia resistance, 6; source, C 817 (a derivative of GW 359-52R, an LSR commercial variety); current seed no., SP 691247-00 (germination, approx. 108 s/g).

Suggested utilization: Increase; make experimental hybrids; use in breeding work as a source of genes for Rhizoctonia resistance.

Item 16. FC 703 Multigerm 1.25 pounds

Rhizoctonia resistant; F₂ of the cross, FC 702 x FC 701; about 25% rr; total number of cycles of selection for Rhizoctonia resistance, 5 (i.e. 4 in the development of FC 701 and FC 702, and 1 in the F₁ generation); sources, GW 674-56C and C 817; current seed no., SP 691001-0 (germination, approx. 106 s/g). FC 701 and FC 702 are lower in yielding ability than the source varieties. The cross (FC 702 x FC 701) was made on the assumption that the resultant broader base could provide higher potentials for productivity and Rhizoctonia resistance than either parent, alone. In a replicated test in the leaf spot field at Fort Collins in 1968, the F₁ significantly exceeded FC 701 and FC 702 in gross sucrose yield and equaled or exceeded the source varieties in gross sucrose yield and sucrose percentage.

Suggested utilization: Increase; use in breeding work as a source of genes for Rhizoctonia resistance.

(Seed supplies of FC 701/4, FC 702/4, and FC 703, as listed above, are already on hand at Fort Collins, and distribution can be made at any time.)

III. Plant Industry Station, Beltsville, Maryland.

Developments in breeding research of G. E. Coe:

Item 17. SP 7042-0 Monogerm 1 pound

Type 0 with moderate resistance to leaf spot and black root. It has short seed stalks, and seed production is rather low. Maintainer line for SP 7042-01 MS.

Item 18. SP 7042-01 MS Monogerm 1 pound

Male-sterile companion line of SP 7042-0. Progenitor of this line SP 6442-1 performed well in combination with SP 6322-0 at Alma, Michigan in 1968.

Suggested utilization: Production of more experimental hybrids, particularly (SP 6923-01 mm MS x SP 7042-0) x multigerm pollinator.

UTILIZATION OF USDA SEED RELEASES, 1970

Item numbers and seed numbers are identical with those listed by the Leader, Sugarbeet Investigations, USDA, dated May 13, 1970 under subject "Proposals for Seed Production and Utilization."

I. U. S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, R. T. Lewellen and I. O. Skoyen.

Item 1. C910 Multigerm 50 grams

The available quantity of seed will be shared now among the following companies: Amalgamated, American Crystal, F & M Association, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 2. C0705 Monogerm 1 pound

From the available amount of seed, a portion will be shared now among the following companies: Amalgamated, 10 grams; American Crystal, 10 grams; F & M Association, 10 grams; Holly, 15 grams; Spreckels, 15 grams; and Utah-Idaho, 10 grams. The balance of the seed will be used for an increase by the West Coast Beet Seed Company for American Crystal, Great Western, Holly, Spreckels and Union.

Item 3. C0705H0 Monogerm 1 pound

The same utilization and distribution as noted for Item 2 will apply to this number.

B. Developments in breeding and genetic research by V. F. and Helen Savitsky.

Item 4. S-5-692-2 Multigerm 2 pounds

The available quantity of seed will be shared now among the following companies: Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 5. S-3-519 Multigerm 250 grams

The available quantity of seed will be shared now among the following companies: Amalgamated (15 grams only), American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho (15 grams only).

Utilization of USDA Seed Releases, 1970
Page 2

Item 6. S-4-563 Monogerm 250 grams

The available quantity of seed will be shared now among the following companies: Amalgamated (15 grams only), American Crystal, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 7. S-4-971 Multigerm 200 grams

The same utilization and distribution as noted for Item 6 will apply to this number.

Item 8. S-4-601 Multigerm 200 grams

The same utilization and distribution as noted for Item 6 will apply to this number.

Item 9. S-4-936 Multigerm 200 grams

The available quantity of seed will be shared now among the following companies: Amalgamated (15 grams only), American Crystal, F & M Association, Great Western, Holly, Spreckels, Union and Utah-Idaho.

Item 10. S-4-929 Multigerm 150 grams

The same utilization and distribution as noted for Item 6 will apply to this number.

Item 11. S-4-908 Multigerm 150 grams

The same utilization and distribution as noted for Item 6 will apply to this number.

Item 12. S-4-903 Multigerm 200 grams

The same utilization and distribution as noted for Item 6 will apply to this number.

Item 13. S-5-537-5 Monogerm 200 grams

The same utilization and distribution as noted for Item 9 will apply to this number.

Utilization of USDA Seed Releases, 1970

Page 3

II. Crops Research Laboratory, Colorado State University, Fort Collins, Colorado.

A. Developments in breeding research of J. O. Gaskill.

Item 14. FC 701/4 Multigerm 3 pounds

The available quantity of seed will be shared now among the following companies: Amalgamated (50 grams only), American Crystal, Great Western, Holly, Spreckels and Utah-Idaho.

Item 15. FC 702/4 Multigerm 4 pounds

The available quantity of seed will be shared now among the following companies: Amalgamated (50 grams only), American Crystal, Great Western, Holly, Spreckels and Utah-Idaho (50 grams only).

Item 16. FC 703 Multigerm 1.25 pounds

From the available amount of seed, a portion will be shared now among the following companies: Amalgamated, Holly, Spreckels and Utah-Idaho who want 50 grams each and American Crystal, F & M Association and Great Western who want 15 grams each. The balance of the seed will be used for an increase by the West Coast Beet Seed Company--Spreckels receiving 3 pounds and the rest of the increase to be shared by American Crystal, F & M Association, Great Western and Holly.

III. Plant Industry Station, Beltsville, Maryland.

A. Developments in breeding research of G. E. Coe.

Item 17. SP 7042-0 Monogerm 1 pound

The available quantity of seed will be shared now among the following companies: Amalgamated, American Crystal, F & M Association, Great Western, Holly, Spreckels and Utah-Idaho.

Item 18. SP 7042-01 MS Monogerm 1 pound

The same utilization and distribution as noted for Item 17 will apply to this number.

ABSTRACTS OF PAPERS APPROVED FOR PUBLICATION IN 1970

BENNETT, C. W. The curly top disease of sugarbeet and other plants. Phytopathology: Monograph 7 (In press).

This article, prepared at the invitation of the American Phytopathological Society for its Monograph Series, contains a summary of available information on the curly top disease from the time of its discovery up to the present time.

DONEY, D. L. and E. D. WHITNEY. Genetic diversity in sugarbeet lines selected for nematode resistance. J. Am. Soc. Sugar Beet Technol. (In press).

Eight, heterozygous, genetic-divergent populations were divided into two groups and all possible crosses made within groups. Field tests involving all crosses and parents revealed significant general combining-ability variances among heterozygous populations for root yield, percent sugar, and gross sugar. A significant specific combining-ability variance was observed for gross sugar only. There were significant differences in mean heterosis between these heterozygous populations. Those populations believed to be the most genetically divergent exhibited the most heterosis.

DONEY, D. L., E. D. WHITNEY, and A. E. STEELE. Effect of *Heterodera schachtii* infection on sugarbeet leaf growth. Phytopathology 61(1): 40-41. 1971.

A significant increase in petiole length was observed in nematode-infected over non-infected sugarbeet plants 8 and 9 weeks after inoculation with *Heterodera schachtii* larvae. The average size of the spongy parenchyma cells of the petioles (measured with a phase-contrast microscope) was significantly greater in the nematode-infected plants ($1.44 \times 10^{-4} \text{ mm}^2$) than in healthy plants ($0.79 \times 10^{-4} \text{ mm}^2$). A highly significant correlation coefficient of 0.89 was obtained between cell size and length of petioles. No difference was found in the lower epidermal cells of the leaf between healthy and nematode-infected plants.

DONEY, D. L., J. M. FIFE, and E. D. WHITNEY. Quantitative relationships of free amino acids in fibrous roots of nematode infected sugarbeet. J. Am. Soc. Sugar Beet Technol. (In press).

The concentration of aspartic acid, glutamic acid, and glutamine was measured in nematode-infected and noninfected plants of nine heterozygous and two homozygous sugarbeet populations. Significant increases in concentration of these three amino acids were found in the fibrous root juice of sugarbeet seedlings 4 weeks after inoculation with *Heterodera schachtii* larvae, compared with healthy plants of the same age. No measurable nematode effect on tap and fibrous root weights was

observed at this stage of infection. Significant genotypic variances were obtained for the concentration of the three amino acids tested for tap and fibrous root weights. Significantly larger environmental and genotypic variances were obtained under nematode conditions than under healthy conditions. Tap and fibrous root weights were positively correlated. Aspartic acid, glutamic acid, and glutamine were negatively correlated with tap and fibrous root weights and positively correlated with each other. Only tap root weight showed any association with nematode counts.

DUFFUS, JAMES E., F. W. ZINK, and R. BARDIN. Natural occurrence of sowthistle yellow vein virus on lettuce. Phytopathology 60(9): 1383-1384.1970.

Sowthistle yellow vein virus (SYVV), described from California and the British Isles on Sonchus oleraceus, has been found in a high percentage of Lactuca sativa plants in some fields in the Salinas Valley. Symptoms induced by SYVV on field lettuce are characterized by vein-clearing and vein yellowing, especially of the tips of affected leaves. Field observations indicate that the virus can cause stunting of affected plants and crop loss. Sowthistle is the principal source of the virus and the vector, Hyperomyzus lactucae, from which lettuce is infected. There is no evidence that the virus is seed-borne in lettuce.

DUFFUS, JAMES E. and G. E. RUSSELL. Serological and host range evidence for the occurrence of beet western yellows virus in Europe. Phytopathology 60(8): 1199-1202. 1970.

Observations of symptoms on weeds and crop plants in Britain during 1968 and 1969 suggested that beet western yellows virus (BWYV) was present in hosts reported to be immune to beet mild yellowing virus (BMV). Transmissions from plants showing BWY-like symptoms, using Myzus persicae as vector, demonstrated that they were infected with a persistent aphid-transmitted virus resembling BWYV in transmission characteristics and host range. The host range of virus isolates from Capsella bursa-pastoris and lettuce growing in eastern England was similar to that of some BWYV strains from California, but differed in several important respects from that of BMV. The three isolates studied in detail infected and produced symptoms on Beta macrocarpa, Brassica rapa, Lactuca sativa, Capsella bursa-pastoris, Nicotiana clevelandii, and Claytonia perfoliata, but did not infect Beta vulgaris, Raphanus sativus, Chenopodium capitatum, or Sonchus oleraceus. These three English isolates were readily transmitted by M. persicae, which had acquired virus by feeding on clarified sap through artificial membranes. In density-gradient columns containing sap from infected plants, the positions of infectious zones corresponded closely with those in gradients containing BWYV. In infectivity-neutralization tests, antisera prepared against seven strains of BWYV neutralized infectivity of the English isolates, and specific antisera against the isolates neutralized infectivity of five BWYV strains as well as the isolates. Antisera prepared against sap from virus-free plants did not affect the infectivity of any virus strain or isolate. The results of these investigations show for the first time that BWYV occurs outside the USA, but do not help to clarify the relationship between BWYV and BMV.

ESAU, KATHERINE and LYNN L. HOEFERT. Composition and fine structure of minor veins in Tetragonia leaf. Protoplasma (In press).

Mesophyll containing the minor veins from leaves of Tetragonia expansa Murr. was examined in preparation for a study of effects of beet yellows virus on the leaf tissues of this plant. The sieve elements throughout the minor veins exhibit the characteristics commonly found in this type of cell in dicotyledons. The cells are connected with one another by sieve plates and with contiguous parenchyma cells by branched plasmodesmata. Mature sieve elements are enucleate and lack ribosomes. No tonoplast was discerned in these cells. Mitochondria, plastids, and sparse endoplasmic reticulum are retained in mature cells. The plastids, which contain a massive fibrous ring of proteinaceous material, resemble the sieve element plastids of Beta. The P-protein in the sieve elements is occasionally composed of tubules; more commonly it is represented by loose helices. The tracheary elements have scalariform secondary thickenings. In regions free of these thickenings, the primary wall largely disintegrates; only some loosely arranged fibrils remain. The mesophyll and vascular parenchyma cells contain the various organelles characteristic of living plant cells but vary in degree of vacuolation and in density of cytoplasm. Some vascular parenchyma cells have particularly dense protoplasts. They contain numerous ribosomes and their background matrix consists of a dense population of fine fibrils. Occasional vascular parenchyma cells contain the tubular spiny cell component first recognized in Beta.

ESAU, KATHERINE and LYNN L. HOEFERT. Cytology of beet yellows virus infection in Tetragonia. I. Parenchyma cells in infected leaf. Protoplasma (In press).

The distribution of beet yellows virus in parenchyma cells of Tetragonia expansa Murr. leaves and the pathologic changes in these cells were studied with light and electron microscopes. Leaves of various ages obtained from systemically infected leaves were used. Virus particles occurred in parenchyma cells of the veins and the mesophyll. In younger leaves virus particles were seen only in the cytoplasm, in older leaves also in the nuclei. The earliest abnormality in infected cells was the formation of vesicles which occurred in aggregates as large as or larger than the nuclei. In the highly vacuolated mesophyll cells, the aggregates protruded into vacuoles and assumed the form of amorphous inclusion bodies as seen with the light microscope. The vesicle aggregates contained virus particles and the vesicles networks of fine fibrils. The chloroplasts were not materially affected by the infection except when the entire cell was undergoing necrosis. Mitochondria assumed ameboid forms in some cells, but appeared normal in most others. Certain membrane-bound enclaves, containing fragments of membranes, seemed to have been derived from mitochondria. Nuclei containing virus aggregates showed no obvious abnormalities. In some cells ribosomes appeared to be degenerating.

ESAU, KATHERINE and LYNN L. HOEFERT. Cytology of beet yellows virus infection in *Tetragonia*. II. Vascular elements in infected leaf. Protoplasma (In press).

This second paper in the series dealing with the ultrastructure of *Tetragonia expansa* Murr. infected with the beet yellows virus considers the relation of the virus to the conducting cells in the phloem and the xylem. Virus particles occurred in mature sieve elements, their amount increasing as the infected leaf became older. In later stages of infection some sieve elements became completely blocked with virus. Virus particles were seen in pores of sieve plates and in plasmodesmata interconnecting sieve elements and parenchyma cells. Tracheary elements, mature and immature ones, also contained virus particles. Presence of inclusions composed of vesicles and virus in some immature tracheary elements seems to indicate that virus multiplies in these cells. In contrast, no vesicles and no virus particles were discovered in immature sieve elements.

ESAU, KATHERINE and LYNN L. HOEFERT. Cytology of beet yellows virus infection in *Tetragonia*. III. Conformations of virus in infected cells. Protoplasma (In press).

In this third paper of the series dealing with beet yellows virus infection of *Tetragonia expansa* Murr, the different kinds of aggregates of virus and the state of the virus particles in the different cells are examined. In vascular parenchyma cells, the aggregates of virus are variable but are consistently intermingled with host cell components. In the sieve elements, the virus may fill the cell lumen solidly either without obvious order or in stacks of layers each as wide as the particle is long. The virus particles appear to be disorganizing in degenerating parenchyma cells and in sieve elements in which the virus becomes solidly packed.

GASKILL, J. O., D. L. MUMFORD, and E. G. RUPPEL. Preliminary report on breeding sugarbeet for combined resistance to leaf spot, curly top, and *Rhizoctonia*. J. Am. Soc. Sugar Beet Technol. (In press).

Replicated sugarbeet field experiments were conducted at Fort Collins, Colorado, in 1968 and 1969 and at Logan, Utah, in 1969 to study the inheritance of resistance to *Rhizoctonia* root and crown rot and the feasibility of combining resistance to leaf spot, curly top, and *Rhizoctonia*. With respect to *Rhizoctonia*, the results obtained for one F₁ hybrid indicated nearly complete dominance of resistance. The resistance of a similar F₁ hybrid was loosely classed as intermediate. Results for a series of 18 F₃ populations indicated, tentatively, that *Rhizoctonia* resistance can be transferred from resistant to susceptible material with relative ease. The following tentative conclusions were drawn from results obtained for the F₃ populations in all three experiments: (a) resistance to leaf spot, curly top, and *Rhizoctonia* root and crown rot is inherited independently; and (b) it is feasible to combine genetic resistance to these three diseases in the same sugarbeet strain.

HECKER, R. J. Inbreeding depression in diploid and autotetraploid sugarbeet, *Beta vulgaris* L. Crop Science (In press).

The effect of inbreeding on vegetative vigor, as measured by root yield, was evaluated in two diploid (2n) and equivalent autotetraploid (4n) sugarbeet strains, and one additional 2n and one 4n strain. Root yields of the 2n and 4n S₁ progenies each averaged 86.7% of their comparable open-pollinated progeny. Inbreeding depression of root yield was variable from strain to strain. The selfed 4n populations, when compared with their 2n equivalents, suffered more yield depression than was expected on the basis of the theoretic approach to homozygosity associated with selfing in autotetraploids. The inbreeding depression was partly attributed to (a) the approach to homozygosity, and (b) the fact that partially homozygous 4n S₁ individuals were probably unable to make compensating growth when located adjacent to a low vigor aneuploid plant. A major part of root yield depression remained unexplained. Sucrose content within strains and within ploidy levels was not significantly affected by one generation of selfing.

HOEFERT, LYNN L., KATHERINE ESAU, and JAMES E. DUFFUS. Electron microscopy of *Beta* leaves infected with beet yellow stunt virus. Virology 42: 814-824. 1970.

Beta vulgaris L. leaves infected with beet yellow stunt virus contain flexuous rods resembling the particles of beet yellows virus. The rods usually occur in the cytoplasm and form aggregates of various sizes. They tend to be arranged parallel to one another in the aggregates and may also form parallel layers within the larger aggregates. Thus far, the rods were seen only within the phloem, in parenchyma cells associated with sieve elements, and in mature sieve elements. The rods are assumed to be the virus particles. Degenerative changes were observed in chloroplasts of mesophyll and phloem parenchyma and in plastids of sieve elements. The presumed virus particles were absent in these cells. Some phloem parenchyma cells with virus either present or absent underwent complete breakdown.

HOEFERT, L. L. Flexuous rods in vascular tissue of *Sonchus* infected with beet yellow stunt virus. 7th Intern. Congr. Electron Micros., Grenoble. 3: 317-318. 1970.

Beet yellow stunt virus was first described by Duffus in 1964. The disease affects sugarbeet (*Beta vulgaris* L.), lettuce (*Lactuca sativa* L.), and commonly occurs in sowthistle (*Sonchus oleraceus* L.) which serves as a natural reservoir of the virus. Healthy *Sonchus* plants were inoculated with beet yellow stunt virus by means of the aphid vector, *Hyperomyzus lactuca* (L.). Leaf tissues were fixed in paraformaldehyde-glutaraldehyde, postfixed in 2% osmium tetroxide, dehydrated in acetone, and embedded in epon epoxy resin. It was considered important to investigate the effects of the virus on cells of the *Sonchus* host and to correlate these findings with the observed effects of beet yellow stunt virus on

sugarbeet. Flexuous rods were seen in the phloem parenchyma and sieve elements of vascular tissue in infected leaves. Specialized phloem parenchyma cells or transfer cells also contained large accumulations of flexuous rods. Figure 1 shows a portion of a transfer cell from a vein of an infected leaf. Large numbers of flexuous rods are evident in the cytoplasm along with the usual cytoplasmic constituents--mitochondria, vacuoles, ribosomes, and a portion of the nucleus. In the second figure, a large accumulation of flexuous rods is seen in the cytoplasm of a transfer cell adjacent to a sieve element. Wall projections are evident in the transfer cell cytoplasm, and some organelles--mitochondria, endoplasmic reticulum, and paramural or multivesicular bodies. Figure 3 shows two sieve elements flanked by two transfer cells and a parenchyma cell, all of which contain flexuous rod particles. The particles can be seen entering the sieve plate pores of one sieve element. Although transfer cells have been described in Sonchus, I know of no description of virus particles in such cells. Sieve elements have been shown to contain beet yellows virus and tobacco mosaic virus, and here are shown to contain flexuous rods associated with beet yellow stunt virus infection as well. If, as Gunning et al. have suggested, the transfer cell is specialized for uptake of solutes and also serves a function in the export of photosynthates, then the present report may indicate that the transfer cell aids in movement of virus from the phloem along with photosynthates. Further studies on young developing tissues of Sonchus could elucidate more fully the transfer process and lead to a better understanding of transfer cell function.

McFARLANE, J. S. Research project of the USDA sugarbeets investigation. Sugar Journal 32(11): 26. 1970.

A popular article describing the research activities of Sugarbeet Investigations.

MUMFORD, D. L. and W. E. PEAY. Curly top epidemic in western Idaho. J. Am. Soc. Sugar Beet Technol. (In press).

A major cause of an outbreak of curly top in western Idaho in 1969 was the movement of an unusually high population of viruliferous beet leafhoppers into the affected area 3 to 4 weeks earlier than normal. The increased prevalence of more virulent strains of curly top virus was clearly indicated and is suggested as a major factor in the increased frequency of curly top outbreaks in recent years.

NELSON, J. M. and E. G. RUPPEL. The effect of manure on sprangling of sugarbeet roots. J. Am. Soc. Sugar Beet Technol. (In press).

Field applications of manure at rates of 40 tons per acre or higher were associated with a high incidence of sprangling. These rates are generally much higher than those used commercially. For comparable treatments, plants grown in the greenhouse had a higher incidence of sprangling than those in field plots. Sterilized manure caused the same

incidence of sprangling in nonsterilized manure, indicating that micro-organisms in manure are not the direct cause of sprangling. When leached manure was used in manure-soil mixtures, sprangling tended to be less severe. Irrigating seedlings with a manure leachate resulted in some sprangled roots.

RUPPEL, E. G. Longevity of *Cercospora beticola* conidia under different storage conditions. Mycologia. (In press).

Spores of *Cercospora beticola* remained pathogenic and 100% viable in aqueous suspension under refrigeration (2-3 C) for 14 days. Viability remained near 100% up to 28 days, but declined rapidly between 28 and 34 days. Spores sedimented by centrifugation, dried over CaCl_2 , and stored over CaCl_2 at 2-3 C or at room temperature (ca. 25 C) were not viable after 4 months. However, 9% germination was obtained with similarly treated spores stored in a freezer (0 C). Spores frozen in aqueous suspension were not viable after 4 months. Storage of *C. beticola* in the form of prepared inoculum is a convenient and simple way to achieve greater flexibility in inoculation schedules. Other more sophisticated storage techniques (e.g. lyophilization) would be too tedious and time consuming for use in a routine breeding program.

RUPPEL, E. G. and J. O. GASKILL. Techniques for evaluating sugarbeet for resistance to *Cercospora beticola* in the field. J. Am. Soc. Sugar Beet Technol. (In press).

About 8 kg of dried, *Cercospora beticola*-infected leaves, collected the previous year from sugarbeet lines varying in degree of resistance, are wetted and rubbed together by hand in 13 gal of water to free spores. The resultant suspension is screened and diluted to 50 gal with water. The diluted suspension is sprayed on beet foliage, usually early in July, at 100 psi and a rate of 50 gal/acre. Foliage is kept wet for 2 to 3 days after inoculation by intermittent overhead irrigation. Sprinkling for 2 or 3 days a week is resumed after primary leaf spots appear (ca. 2 weeks after inoculation). Disease ratings of 0 to 10, based on an ascending order of severity, are made at the peak of the epiphytotic during secondary cycles of infection, about 5 to 8 weeks after inoculation. Two-row x 12 ft plots are preferred for varietal evaluations. Individual resistant plants in segregating populations are staked for selection purposes. The number of spores applied per linear foot of row has varied from 2.5×10^5 in 1969 to 1.7×10^6 in 1970. Satisfactory epiphytotics occurred in both years. Spore counts in 1970 of stock and diluted inoculum indicated 99.3×10^4 and 21 to 23×10^4 spores/cc, respectively. Viability tests indicated only 2% germination in the stock suspension, whereas 49% of the spores germinated in the diluted inoculum. These techniques for creating a leaf spot epiphytotic in the field, and for evaluating resistance of sugarbeet lines and individual plants, are characterized by their simplicity, reliability, and economy. The techniques may be applicable in research on other leaf spot diseases.

RYSER, G. K. and J. C. THEURER. Impurity index selections on individual sugarbeets. J. Am. Soc. Sugar Beet Technol. (In press).

The merit of utilizing an economical and easy method of individual sugarbeet selection for high and low sugar percentage and high and low impurity index was evaluated at Logan and Farmington, Utah. Recurring selections using Mendelian male sterility as a crossing tool resulted in positive selection pressure for all factors studied. Self-fertile progenies selected on an individual beet basis gave varied results, probably due to inbreeding and fixing of the genes. Progress in the direction of low quality selection was easier to accomplish than was selection toward high quality. The impurity index was an effective breeding tool for improving the beet purity of a line and still maintaining high sugar percentage.

SCHNEIDER, C. L. and H. S. POTTER. Results of field tests in Michigan to control sugarbeet diseases. Fungicide and Nematicide Tests - Results of 1969 25: 98-100. 1970.

Benomyl was the most effective among 17 treatments tested in controlling leafspot incited by Cercospora beticola. The only seed and soil treatments that controlled seedling blight incited by Aphanomyces cochlioides were those containing DASS (p-dimethyl-amino-benzenediazo sodium sulfonate). Among 17 seed, soil and spray treatments tested, PCNB and benomyl effectively controlled crown and root rot incited by Rhizoctonia solani when applied as sprays in the crowns.

SMITH, G. A. and J. O. GASKILL. Inheritance of resistance to Cercospora leaf spot in sugarbeet. J. Am. Soc. Sugar Beet Technol. 17(1) (In press).

Estimates of the heritability of resistance to Cercospora leaf spot in sugarbeet and the number of genes controlling resistance were made by means of one leaf spot resistant and two susceptible lines, three F_1 populations, and three F_2 populations. Individual-plant leaf spot ratings were made on a total of 2,880 plants in a randomized block experiment with 40 replications in each of 2 years. Results indicated that a minimum of 4 or 5 pairs of genes control resistance to leaf spot and that, under less severe epidemic conditions, some genes may fail to function or function at a much lower level than others. Broad sense heritability estimates indicated that 60 to 71 percent of the variation in the F_2 populations was genetic in nature. Frequency distributions of the F_1 and F_2 populations, and the means of the F_1 and parental populations, suggested that part of this genetic variation was due to non-additive gene action.

SMITH, G. A. and R. J. HECKER. Predicting double-cross sugarbeet hybrid performance. Crop Sci. 11(1): 106-108. 1971.

Thirty-five double crosses, 15 single crosses, and six red beet top crosses were developed from six inbred lines and used to test five methods of predicting double-cross sugarbeet (Beta vulgaris L.) hybrid

performance. The mean of the four non-parental single crosses of any double cross was found to be the most consistent method for predicting root yield and percent sucrose. Percent purity was best predicted by the mean of all six single crosses of the parents involved in any double cross. However, predictive capabilities of five methods studied were not greatly different. There was little relationship between the correlation coefficients and the percentage of accurately predicted top performing hybrids.

SNYDER, F. W. Effect of leaf area and nitrogen on root weight and sucrose of sugarbeets. J. Am. Soc. Sugar Beet Technol. 16(1): 8-25. 1970.

Single sugarbeet plants were grown outdoors in large tiles filled with sand and vermiculite and supplied with mineral nutrient solution. Data on individual plants indicated a large range in genetic potential. Within the range of 2 to 512 cm², leaf area doubled rather consistently every three days. Leaf areas, obtained from approximately 40 to 100 days after planting, generally did not correlate very well with each other nor with the weights of the plant parts at harvest. The correlations improved as the samplings were made closer to harvest. Withholding of nitrogen after August 2 reduced leaf area significantly by harvest and tended to reduce root weights, but not statistically significant (5% level) in the 1962 experiment. Sucrose in the roots of plants deficient in nitrogen increased sufficiently to equal or exceed total sucrose in roots of plants on continuous nitrogen. Crown weights were reduced considerably by restricting nitrogen nutrition.

STANDER, J. R. and J. C. THEURER. Inheritance and linkage of a virescens and a chlorina in Beta vulgaris L. Crop Sci. 10(5): 548-549. 1970.

Inheritance and linkage relationships were studied for a chlorina and a virescens in sugarbeets, Beta vulgaris L. The virescens differed from the types previously reported as to the color of the affected leaves and the time required to develop normal pigmentation. It was conditioned by a simple recessive gene designated vi₄. Chlorina from irradiated SLC 03 seed was the same as ch₂ chlorina. Its inheritance as a simple recessive was confirmed. Linkage data showed independent inheritance for vi₄ with factors for yellow pigmentation (y), red pigmentation (R), annual growth habit (B), Mendelian male sterility (a₁), and ch₂. The ch₂ gene showed independence with R, a₁, and vi₄.

TAKEDA, T., R. T. LEWELLEN, and I. O. SKOYEN. Yield reductions due to virus yellows infection of sugarbeet seedlings in a transplant nursery. Japanese Bulletin of Sugar Beet Research, Supplement No. 12. (In press).

The effects of virus yellows infection in sugarbeet seedlings prior to being transplanted were investigated at Salinas, California, in 1969. A combination of beet yellows and beet western yellows viruses was used as inoculum and the plants were inoculated and transplanted in the cotyledon and 4-leaf stages of growth. Comparisons were made between

the yield performance of infected and noninfected plots. The infection in seedling beets caused a highly significant reduction in root yield and gross sugar with mean losses being 47.0 and 48.5%, respectively. Differences between stages of growth and the treatment interaction were not significant.

THEURER, J. C. Variability in partial male-fertile sugarbeet. J. Am. Soc. Sugar Beet Technol. (In press).

Studies on the variation and inheritance of partial male sterility in the sugarbeet were conducted in our laboratory at Logan, Utah. We were unable to select stable partial-fertile lines having a given degree of fertility. Segregation of F₂ and F₃ progenies of a single partial-fertile plant demonstrated that the inheritance of partial male sterility was extremely complex. Seven crosses of F₂ male-sterile segregates with the annual type O pollinator SLC 03, and four crosses of F₂ male-sterile segregates with SLC 129 showed that white-anther male-sterile plants, even though they appear phenotypically similar, are genotypically different. Critical studies utilizing clonal or isogenic material under highly controlled environmental conditions will be required to elucidate the complex inheritance of partial male sterility in the sugarbeet.

THEURER, J. C. Inheritance studies of a pollen restorer from Ruby Queen table beet. J. Am. Soc. Sugar Beet Technol. (In press).

A strong pollen-restorer gene was derived from the Ruby Queen variety of table beet. In crosses with the annual tester SLC 03 CMS, it shows monogenic inheritance. Data indicate that the widely used tester line, SLC 03 CMS, possibly carries minor modifier genes which influence the degree of pollen fertility when this line is crossed to the Ruby Queen restorer inbred.

WHITNEY, E. D. and D. L. DONEY. Effects of Aphanomyces cochlioides and Pythium ultimum, alone and in complexes, with Heterodera schachtii on sugarbeet. J. Am. Soc. Sugar Beet Technol. (In press).

The data suggest that synergistic effects between Heterodera schachtii and Aphanomyces cochlioides reduced yield and sucrose but increased sprangling of roots during some years.

WHITNEY, E. D. The first confirmable occurrence of Urophlyctis leproides on sugarbeet in North America. Plant Disease Reprtr. 55(1): 30-32. 1971.

The identification of Urophlyctis leproides causing tumors on leaves and crowns of beet at Milpitas, Santa Clara County, California, constitutes the first positive occurrence of the disease in North America. The validity of previous listings of the occurrence of the disease on beet is discussed. A pictorial description of the symptoms of beet tumor and of the causal organism is included.

WU, M. T., B. SINGH, J. C. THEURER, and D. K. SALUNKE. Control of sugar loss in sugarbeet during storage by chemicals and modified atmosphere and certain associated physiological changes. J. Am. Soc. Sugar Beet Technol. (In press).

Pre-harvest foliar sprays of the plants; post-harvest dips of the roots; and modified (high CO₂ and low O₂) atmosphere storage of roots were tested for effectiveness in reducing the loss of sugar in sugarbeet roots during storage. The pre-harvest foliar application of Radox; the post-harvest dips in N⁶ - benzyladenine and Radox solutions; and the modified atmosphere storage of roots, each produced similar responses: (1) reduced loss of sucrose, (2) reduced concentration of raffinose, and (3) reduced rate of respiration.

SUGARBEET RESEARCH

1970 Report

Section B

U.S. Agricultural Research Station, Salinas, California

Sugarbeet Investigations

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Holly Sugar Corporation
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CONTENTS

	Page
SUMMARY OF ACCOMPLISHMENTS, 1970	B2
DEVELOPMENT OF VARIETIES AND BREEDING LINES FOR CALIFORNIA	
Field tests, Salinas, California	B6
Field tests, Brawley, California	B22
Field test, American Crystal Sugar Company	B28
Field tests, Spreckels Sugar Company	B29
Field tests, Union Sugar Division	B32
BREEDING FOR NEMATODE RESISTANCE	
Summary of nematode resistance breeding research 1966-70 by D. L. Doney and E. D. Whitney	B35
Nematode trials, 1970 by D. L. Doney, I. O. Skoyen, and E. D. Whitney	B44
NEMATOLOGY INVESTIGATIONS by Arnold E. Steele	
Influence of inoculum level on development of <u>Heterodera schachtii</u> on sugarbeet	B49
Influence of inoculum level of <u>Heterodera schachtii</u> and environment on cyst production and growth of sugarbeet . .	B52
Influence of root size on development of <u>H. schachtii</u> on sugarbeet	B55
Penetration and development of the sugarbeet nematode on defoliated sugarbeets and on root debris	B57
Gross morphological changes in roots of young sugarbeet infected or not infected with the sugarbeet nematode	B57
Emergence of adult male <u>Heterodera schachtii</u> from sugarbeet maintained in liquid nutrient solution	B59
Attempts to extract hatch factor from sugarbeet root diffusate with alcohol and ether	B60
INTERSPECIFIC HYBRIDIZATION	
<u>Vulgaris-procumbens</u> hybrids by Helen Savitsky	B64
<u>Vulgaris-cocciliflora</u> hybrids by Helen Savitsky and J. S. McFarlane	B66
VIRUS INVESTIGATIONS by J. E. Duffus	B69
EVALUATION OF CURLY TOP VIRUS FIELD INOCULATIONS ON SUGARBEET by I. O. Skoyen and J. E. Duffus	B71
EFFECTS OF FUMIGATION, FERTILIZER, VARIETY AND CROP ROTATION ON YIELD, SUCROSE AND PURITY OF SUGARBEETS by E. D. Whitney and I. O. Skoyen	B74

SUMMARY OF ACCOMPLISHMENTS, 1970

YELLOW RESISTANCE--The evaluation and selection for yellows resistance was done only at the Salinas station in 1970. In one test (page B17), 15 self-sterile lines and 27 three-way hybrids were inoculated with a combination of BYV-BWYV. The same varieties were evaluated in two adjacent tests (pages B13 and B14) in which aphicides were used to prevent spread of yellows. There was a very low level of natural infection in these two tests. Comparisons between pairs of these inoculated and non-inoculated varieties should provide good estimates of the effects of virus yellows infection. Gross sugar losses varied from 25.2% for Y904AB to 59.4% for 868. Self-sterile lines in which selection for yellows resistance has continued within the 13 and Y03 yellows resistant sources and within lines derived from crosses with these sources showed the highest levels of resistance, e.g., Y904AB, 944, 813, Y803, and 910. Comparisons of losses among the three-way hybrids showed that the hybrids with combinations of both male and female components selected for yellows resistance were generally most resistant, but under healthy conditions usually did not combine for yield as well as hybrids which used 546H3 or 569H3 as the female parent.

A split-block test (page B19) with seven self-sterile lines and US H20 in BYV-BWYV inoculated and noninoculated subplots was grown. Except for ppm K, there were significant interactions between the variety and virus treatments for the components of yield and impurity. These significant interactions indicate that there is a differential response between the varieties when grown under infected and noninfected conditions. Gross sugar losses varied from 14.7% for 813 to 50.0% for US H20. For the components of impurity (NH₂-N, Na, K), yellows infection generally caused an increased concentration. However, within each component, the effect of yellows was variable causing some varieties to decrease and some to increase their concentrations.

Eight self-sterile and 15 self-fertile lines were selected for yellows resistance in 1970. The selection program has emphasized the development of type 0, monogerm inbred lines with resistance to yellows, curly top, and bolting. This program has been unsuccessful to the extent that the most yellows-resistant, self-fertile lines developed have been either multigerm or curly top susceptible. During the past several years renewed effort has been placed on developing new self-fertile source populations in which to select for yellows resistance. These populations are crosses or composites of crosses between the best available sources of curly top and yellows resistance. Hopefully, type 0, monogerm segregates will occur in which desirable combinations of resistance can be selected. In addition, these composites will provide source populations for selection and genetic studies.

Studies on the inheritance of beet mosaic virus resistance were continued. Testcrosses and F₂ ratios indicated that the incompletely dominant gene that conditions resistance is probably linked to the site

of the Mendelian male sterile gene, a_1 . The third backcross of the mosaic resistance gene was made into several self-sterile, yellows-resistant lines. R. T. Lewellen, I. O. Skoyen, J. S. McFarlane.

POLYPLOIDY--Triploid hybrids that utilized tetraploid 413 as the pollinator were evaluated at Salinas, California (page B15). Growing conditions were good and very little yellows infection occurred until late in the season. Root yields tended to be higher and sucrose percentages lower in the triploid hybrids, but rarely were the differences significant. Sugar yields were not significantly better for any of the triploid hybrids compared with the equivalent diploid hybrids. The ploidy level had no significant effect on the amino nitrogen and sodium contents of the roots. Potassium tended to be higher in the triploids and was significantly higher in two of the hybrids.

A major deterrent to the introduction and use of triploid monogerm varieties in the United States is the relatively poor seed germination usually associated with monogerm triploids. Reduced germination also occurs in multigerm triploid hybrids, but a portion of this reduced germination occurs as a reduction in the number of sprouts per seedball. This means that a higher portion of the seedballs in a triploid hybrid give rise to single seedlings as compared with the equivalent diploid hybrid. A test was conducted in 1971 to determine the relative performance of diploid and triploid hybrids when processed seed was space planted and the plants lightly thinned with a long-handled hoe. No significant differences were observed in the yield of the equivalent diploid and triploid hybrids (page B16). Sucrose percentages tended to be higher in the diploids, but the difference was significant for only one diploid-triploid comparison. Some double and a few triple seedlings appeared from single seedballs but the proportion of multiple seedlings was much smaller with the triploid seed. These results suggest that it may be possible to obtain good stands of predominantly single plants with decorticated seed of triploid multigerm hybrids. J. S. McFarlane, I. O. Skoyen, R. T. Lewellen.

VULGARIS-PROCUMBENS HYBRIDS--New resistant trisomic and diploid resistant segregates were selected from the progenies of nematode resistant vulgaris-procumbens trisomics. A total of 92 resistant trisomic plants and 75 diploid plants were selected. These resistant segregates occurred in both the B_2 and B_3 generations. The development of highly resistant diploid plants is of great importance. Their occurrence is attributed to crossing over between B. vulgaris and B. procumbens chromosomes. A segment of a B. procumbens chromosome bearing gene or genes for resistance has been incorporated into a B. vulgaris chromosome.

Cytological studies confirmed the occurrence of crossing over between the two species. Trivalent associations were observed in the meiosis of trisomic plants. H. Savitsky.

VULGARIS-COROLLIFLORA HYBRIDS--Seeds were obtained from 36 highly curly top resistant B₃ segregates from vulgaris-corolliflora hybrids. The number of chromosomes in these resistant segregates varied from 18 to 27, with the majority of the plants possessing 19 and 20 chromosomes. The average number of chromosomes in resistant B₃ plants was reduced compared with the B₂ generation, but high curly top resistance was maintained.

A high level of resistance was also maintained in B₄ progenies. 576 B₄ seedlings were inoculated with two of the most virulent curly top virus strains. Of these, 175 plants showed only mild symptoms and 22 plants had no visible symptoms. These highly resistant plants will be studied cytologically and will be used as a source of resistance for additional hybridization work. H. Savitsky, J. S. McFarlane.

CYTOLOGICAL EFFECTS OF SUGARBEET VIRUSES--Research efforts for the past year have been directed toward elucidating some of the cytological effects of beet yellow stunt virus, a recently-described virus of sugarbeet, lettuce, and certain weed hosts. The virus is transmitted in a semi-persistent manner by aphids and is thus similar in vector relationships to beet yellows virus. We were surprised to find that the morphology of the virus particles was also similar both in cells of sugarbeet and Sonchus oleraceus L., a common weed host.

Some distinct differences in cytological effects of beet yellows and beet yellow stunt were seen with the electron microscope in sugarbeet. Beet yellow stunt induces drastic chloroplast alterations that would point to interesting physiological disturbances were these to be investigated. The virus produced strikingly similar effects on both Sonchus and Beta with regard to presence of viroplasm regions and production of vesicles. Further observations are needed to characterize more fully the similarities and differences between the beet yellows virus and the beet yellow stunt virus, and such studies are anticipated. L. Hoefert.

CURLY TOP VIRUS FIELD INOCULATIONS--Objectives of a preliminary experiment with curly top virus were to develop a method of field inoculation that would insure high infection of plants, to determine the plant age that would produce the highest percent infection, and to determine strain virulence relationships to detectable symptoms in the field. This would permit field test evaluation of yield losses due to late infection, to different levels of curly top virus on susceptible and resistant varieties, and to combined effects on yield of different viruses such as curly top and yellows. Test results showed high infection percentages could be obtained (page B73). Early inoculations (4-week old plants) had the highest percent infection and the greatest reductions in root yield and percent sucrose. I. O. Skoyen and J. E. Duffus.

EFFECT OF ROTATION, SOIL FUMIGATION, AND FERTILIZER--The effects of rotation, soil fumigation, varieties, and fertilizer levels on yield and purity of sugarbeets were studied. First year's results of a projected 3 year study showed beet yield and gross sugar to be highest for first year beets. The greatest increase in yield was with the first increment of fertilizer (80 pounds). Fumigation increased yield more following beets than no beets and was equal to the first increment of fertilizer applied following beets. US H9B was superior to US H7A in yield and tolerance to soil organisms. E. D. Whitney, I. O. Skoyen.

LEAF AND CROWN TUMOR--The first confirmable occurrence of beet tumor of sugarbeet from North America caused by Urophlyctis leproides was reported from Santa Clara County, California. Economic losses from the disease could be expected if inoculum potential is high. E. D. Whitney.

VARIETY TESTS, SALINAS, CALIFORNIA, 1969-70

Location: USDA Agricultural Research Station

Soil type: Sandy loam.

Previous crops: Barley, 1967; fallow, 1968; purple vetch cover crop, 1968.

Fertilizer used: Bolting evaluation tests, planted November 19, 1969.
575 lbs. P/A 0:10:10, preplant, broadcast and disced in before listing.
90 lbs. P/A actual N, as ammonium sulfate, preplant.
60 lbs. P/A actual N, as ammonium sulfate, sidedressed March 13, 1970.
43 lbs. P/A actual N and 57 lbs. P/A Ca, as calcium nitrate, sidedressed April 16, 1970.
60 lbs. P/A actual N, as ammonium nitrate, sidedressed May 28, 1970.

Variety yield tests, planted February 9-10, 1970.
575 lbs. P/A 0:10:10 preplant, broadcast and disced in before listing.
70 lbs. P/A actual N, as ammonium sulfate, preplant.
43 lbs. P/A actual N and 57 lbs. P/A Ca, as calcium nitrate, sidedressed April 16, 1970.
95 lbs. P/A actual N, as ammonium nitrate, sidedressed May 27, 1970.

Yellows resistance evaluation test, planted April 7, 1970.
575 lbs. P/A 15:8:4, preplant, incorporated in the beds.
80 lbs. P/A actual N, as ammonium nitrate, sidedressed June 25, 1970.

2n vs. 3n spaced seed test, planted April 6, 1970.
575 lbs. P/A 0:10:10, preplant, broadcast and disced in before listing.
80 lbs. P/A actual N, as ammonium nitrate, sidedressed June 25, 1970.

Thinning dates: Bolting evaluation tests, January 29, 1970.
Variety yield tests, March 18, 1970.
Yellows resistance evaluation test, May 5, 1970.
2n vs. 3n spaced seed tests, May 5, 1970.

Harvest dates: Bolting evaluation tests, September 14-18, 1970.
Variety yield tests, September 21 - October 5, 1970.
Yellows resistance evaluation test, October 7, 1970.
2n vs. 3n spaced seed tests, October 6, 1970.

Irrigation: As required at 10-14 day intervals starting March 23, 1970.

VARIETY TESTS, SALINAS, CALIFORNIA, 1969-70 continued

Diseases and insects: Virus yellows infection was negligible throughout 1970. The various tests were sprayed from one to four times with Diazinon (1½ pints P/A) and once or twice with Meta-systox R (2 pints P/A) for control of leafminer and aphids. These applications were made between March 20 - August 10, 1970.

Experimental design: Two bolting evaluation tests of 36 entries with 5 replications and 72 entries with 4 replications were planted in randomized block design. Single row plots of 53 and 32 feet, respectively, were used. Three February planted yield tests were randomized block designs and one test was a 10 x 10 latin square. Three tests had single-row plots and one had two-row plots. One test of 42 entries was inoculated with yellows viruses. One April planted test was a randomized block design with 5 replications and another test was an 8 x 8 latin square with plots 69 feet long split in half for two virus treatments per replicate. Except for this last test, all plots were 53 feet long planted on beds spaced 28 inches apart.

Sugar analysis: Determined from two samples per plot of approximately ten roots each at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

Remarks: A condition of low pH (below 6.0) occurred in areas of the bolting test and variety yield tests during the season. This was partially corrected by an application of calcium nitrate April 16, 1970.

VARIETY TEST (Spence 170), SALINAS, CALIFORNIA, 1970

(5 replications of each variety)
(Single-row plots)

Planted: November 19, 1969
Harvested: September 15, 1970

Variety	Description	Acre Yield		7/7		8/11		9/11		Beets/ 100'
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	Bolting Percent	Bolting Percent	Bolting Percent	Number	
Y803H4	569H3 x Y603	16,600	49.93	16.7	0.9	3.2	8.5	165		
Y904H4	569H3 x Y804	16,380	50.26	16.3	3.0	12.9	19.8	154		
Y904H8	546H3 x Y804	16,140	47.57	17.0	2.3	7.6	9.6	166		
U913H8	US H9B	15,970	47.65	16.8	5.4	11.5	16.4	165		
Y904H45	718H31 x Y804	15,830	48.39	16.4	3.9	14.4	22.8	159		
F69-613H4	569H3 x C613	15,790	47.88	16.5	3.5	9.9	13.7	162		
713H4	569H3 x 613A	15,680	47.68	16.5	0.7	4.4	7.1	156		
813H46	718H32 x 713A	15,640	47.69	16.5	0.8	4.1	7.2	154		
813H8	546H3 x 713A	15,560	47.33	16.5	0.7	5.0	7.2	161		
Y904H49	760H33B x Y804	15,450	46.03	16.8	9.3	22.5	30.2	165		
U813H4	US H9A	15,440	47.38	16.3	2.1	7.2	12.5	164		
Y904H50	705H30 x Y804	15,430	47.45	16.3	5.2	16.2	24.8	162		
813H45	718H31 x 713A	15,400	46.63	16.5	2.5	7.4	11.8	159		
F69-813H4	569H3 x C813	15,400	46.60	16.6	3.7	11.9	16.5	164		
U813H8	US H9B	15,250	46.08	16.6	3.1	9.1	12.3	181		
813H50	705H30 x 713A	15,230	45.84	16.7	0.8	7.7	10.7	154		
813TH40	760H29 x 713T	15,210	49.01	15.5	9.0	18.8	22.4	148		
F69-613H8	546H3 x C613	15,170	46.09	16.5	3.6	10.3	12.5	158		
F69-813H8	546H3 x C813	15,030	44.76	16.8	2.6	10.3	12.2	174		
813TH41	757H32 x 713T	14,980	47.95	15.7	1.8	6.9	10.8	149		
Y904	Inc. Y804	14,960	44.65	16.8	2.7	8.6	13.5	158		
813H44	714H30 x 713A	14,810	44.92	16.5	2.7	10.6	17.7	146		
U913H4	US H9A	14,790	46.81	15.8	3.0	10.1	12.6	162		
F68-613	Inc. 7 YRS US 75 (Inc. C613)	14,480	45.92	15.8	4.2	9.9	11.9	165		

VARIETY TEST (Spence 170), SALINAS, CALIFORNIA, 1970 continued

(5 replications of each variety)
(Single-row plots)

Planted: November 19, 1969
Harvested: September 15, 1970

Variety	Description	Acre Yield		7/7		8/11		9/11		Beets/ 100'
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	Bolting Percent	Bolting Percent	Bolting Percent	Number	
664H2	(MS of NB1 x NB5) x 64 (US H6)	14,390	45.14	16.0	4.5	12.6	18.4	157		
F69-413	Inc. 5 YRS US 75 (Inc. C413)	14,380	45.12	16.0	6.7	16.5	20.9	166		
F68-413	Inc. 5 YRS US 75 (Inc. C413)	14,360	44.19	16.3	4.1	8.7	10.8	162		
S-301-H8	569H3 x A6201	14,210	41.61	17.1	0.9	3.3	5.3	164		
868H4	569H3 x F57-68	14,170	42.16	16.8	4.3	7.4	10.8	158		
F66-413	Inc. 5 YRS US 75 (Inc. C413)	14,130	43.70	16.2	5.8	15.4	19.8	159		
F69-713	Inc. 7 YRS, 1 SS US 75 (Inc. C713)	14,030	43.29	16.3	5.7	12.7	15.4	159		
664H8	546H3 x 64 (US H7A)	13,970	42.30	16.5	5.1	14.3	17.8	168		
664H4	569H3 x 64 (US H7)	13,820	42.15	16.4	3.5	11.5	16.1	165		
Y904H51	734H30 x Y804	13,740	43.89	15.7	12.7	29.0	34.3	153		
813	Inc. 8 YRS, 2 SS US 75 (Inc. 713A)	13,440	39.64	17.1	0.7	1.9	3.2	159		
868	Inc. F57-68 (US 75)	12,680	37.93	16.7	4.1	10.9	15.2	157		
Mean		14,940	45.60	16.4	3.8	10.7	14.8	161		
LSD (.05)		1,272	4.10	0.77	2.97	5.59	6.66	11.2		
Coefficient of Variation		6.81	7.19	3.74	63.34	41.83	35.99	5.58		
F value		3.67**	3.49**	2.07**	6.03**	7.52**	7.78**	2.89**		

**Exceeds the 1% point of significance (F=1.83)

VARIETY TEST (Spence 270), SALINAS, CALIFORNIA, 1970

(4 replications of each variety)
(Single-row plots)

Planted: November 19, 1969
Harvested: September 15, 1970

Variety	Description	Acre Yield		7/7		8/11		9/11		Beets/ 100'
		Sugar Pounds	Beets Tons	Sucrose	Bolting	Bolting	Bolting	Percent	Percent	
				Percent	Percent	Percent	Percent	Percent	Number	
Hybrids and Open-pollinated Lines										
813TH32	716H29 x 713T	16,840	56.50	14.9	3.1	10.6	17.3			154
Y904H8	546H3 x Y804	16,830	52.43	16.1	4.8	10.7	18.1			161
813H48	734H32 x 713A	16,440	49.91	16.5	5.3	13.1	19.9			162
Zwaanpoly		16,230	53.39	15.2	7.5	21.0	25.3			159
613H4	569H3 x 513	16,180	51.65	15.7	4.4	11.3	15.2			159
813TH49	760H33 x 713T	16,000	52.01	15.4	5.4	11.1	15.2			152
813H47	751H31 x 713A	15,870	49.74	16.0	0.0	5.0	8.4			155
Y904A	YRS Y704	15,590	47.74	16.4	6.0	13.8	17.6			159
Y904B	YRS Y704	15,400	47.35	16.3	2.9	8.3	11.6			162
Y804	Inc. Y704	15,330	48.89	15.7	6.6	10.6	13.1			148
944	YRS 744	15,310	47.77	16.0	13.9	22.8	29.8			158
813H42	704H29 x 713A	15,250	46.53	16.4	4.4	8.4	12.4			159
7760H33A	716H0 x 760	15,180	46.40	16.4	9.6	20.9	30.8			154
9111	813, 413 x Y704, Y804	15,150	45.48	16.7	0.5	4.5	4.5			166
910	YRS 610	15,150	45.48	16.7	11.8	19.8	27.3			163
Y804H8	569H3 x Y704	15,040	47.48	15.9	5.7	8.6	11.2			151
713	Inc. 7 YRS, 1 SS US 75 (Inc. 613A)	14,910	48.10	15.5	3.9	5.8	7.7			160
713B	8 YRS US 75 (YRS 513)	14,530	48.00	15.1	2.2	7.7	11.4			149
7760H29	754H0 x 760	14,500	44.85	16.2	11.7	25.9	36.6			161
Y803	Inc. Y603	14,470	43.90	16.5	1.1	2.0	4.2			155
911	YRS 511A- x YRS 511A-	14,410	44.00	16.4	1.5	6.3	10.4			158
Y904	Inc. Y804	14,220	44.33	16.1	10.4	20.0	27.4			155
F67-34	Inc. 534	14,210	42.52	16.7	1.0	2.0	4.7			152
7718H32	716H29 x 718	14,060	45.67	15.5	0.5	1.9	5.5			177

VARIETY TEST (Spence 270), SALINAS, CALIFORNIA, 1970 continued

Variety	Description	Acre Yield		7/7		8/11		9/11		Beets/ 100'
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting		Bolting			
					Percent	Percent	Percent	Percent		
813T	Inc. 713T	13,900	45.67	15.2	1.2	3.0	3.0	3.0	133	
915	Inc. 215 (US 15)	13,830	42.66	16.2	9.9	16.6	21.9	21.9	162	
9724H49	YRS 760H33B x YRS 724	13,800	43.28	16.0	8.3	21.4	29.4	29.4	167	
Y907	Inc. 8120, 8129	13,790	44.89	15.4	9.2	21.3	29.0	29.0	162	
7718H31	764H3 x 718	13,730	41.51	16.6	4.1	9.0	13.0	13.0	170	
F66-550H4	563H0 x 550	13,480	40.20	16.8	7.1	10.2	13.3	13.3	152	
9714H46	718H32 x 714	13,480	41.90	16.2	6.7	11.8	16.4	16.4	152	
Y915	Inc. 8168	13,400	41.84	16.0	14.8	21.1	34.3	34.3	149	
F69-546H4	563H0 x 546	13,380	39.67	17.0	4.8	4.8	9.1	9.1	165	
4539H4	US H8	13,350	43.97	15.2	15.4	23.3	28.3	28.3	157	
Y801	YRS Y601	13,240	40.36	16.4	14.1	25.7	31.3	31.3	168	
F68-550H5	564H0 x 550	13,210	39.60	16.9	2.0	4.1	5.1	5.1	155	
959	Inc. 659 (US 56/2)	13,200	42.20	15.7	19.5	34.0	39.5	39.5	156	
921	Inc. 521	13,150	40.79	16.1	14.5	20.1	25.0	25.0	161	
Y908	Inc. 8122, 8131	13,130	42.43	15.5	7.8	14.2	17.6	17.6	156	
F68-546H5	564H0 x 546	13,000	37.60	17.3	1.5	2.4	3.4	3.4	159	
F66-64	Inc. 264	12,940	41.61	15.6	5.0	10.6	13.6	13.6	158	
F68-546H4	563H0 x 546	12,890	38.42	16.9	2.0	5.3	8.1	8.1	166	
8551H4	563H0 x 551	12,860	38.78	16.6	1.9	3.4	6.8	6.8	157	
F69-546H5	564H0 x 546	12,750	37.11	17.2	9.0	15.0	19.0	19.0	155	
Y906	Inc. 8117, 8126	12,660	40.36	15.7	7.5	16.5	23.0	23.0	157	
9714H40	760H29 x 714	12,370	41.11	15.1	33.7	46.2	54.1	54.1	159	
8551H1	564H0 x 551	12,270	37.18	16.6	3.2	6.3	10.5	10.5	150	
Y916	Inc. VDH-9, Acc. 122	12,220	40.29	15.2	17.4	33.1	41.4	41.4	155	
7714H30	760H4 x 714	12,190	35.47	17.2	6.6	10.9	15.1	15.1	167	
F68-546H3	562H0 x 546	12,040	34.81	17.3	3.3	5.5	7.3	7.3	167	
F69-546H3	562H0 x 546	12,020	34.91	17.4	5.1	10.2	13.9	13.9	170	
F67-569H3 (C)	562H0 x 569	11,900	35.80	16.7	2.0	9.0	12.5	12.5	155	

Variety	Description	Acre Yield		7/7		8/11		9/11		Beets/ 100'
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	Bolting Percent	Bolting Percent	Bolting Percent	Number	
7705H30	760H4 x 705	11,760	34.29	17.2	7.5	12.5	17.8		157	
F69-551H5	564H0 x 551	11,750	36.29	16.2	3.6	5.7	7.8		152	
F67-569H3 (D)	562H0 x 569	11,630	33.76	17.3	3.6	8.4	9.4		152	
7705H31	764H3 x 705	11,600	33.63	17.3	6.1	11.2	13.9		166	
940	YRS 540A	11,490	35.57	16.3	15.6	26.9	36.4		158	
8597H1	564H0 x 597	11,230	34.16	16.6	4.1	8.3	11.3		145	
8597H3	562H0 x 597	10,380	31.47	16.6	6.9	12.4	17.2		151	
8536H3	562H0 x 536	10,260	30.97	16.6	25.7	34.4	37.7		138	
8522H2	601H2 x 522	9,690	29.53	16.4	37.7	47.9	51.1		147	
9101A	7102A- x 7102A-	9,480	29.57	16.1	36.9	57.0	65.5		155	
8522H1	564H0 x 522	9,110	27.99	16.3	38.1	45.0	53.0		128	
8536H1	564H0 x 536	8,250	26.51	15.7	39.2	52.2	58.0		135	
<u>Inbred Lines</u>										
F66-569	Inc. 569	10,340	31.17	16.7	12.3	23.3	23.8		148	
F66-562H0	562H0 x 562	10,140	30.09	16.9	7.1	18.1	22.0		159	
F66-562	Inc. 562	9,470	28.61	16.6	10.7	22.3	28.4		152	
F67-563H0	563H0 x 563	9,340	28.22	16.6	5.0	11.2	11.7		159	
F68-564H0	564H0 x 564	8,990	27.56	16.4	7.3	15.3	18.7		155	
F67-564H0	564H0 x 564	8,970	27.20	16.6	6.2	10.9	13.4		141	
F67-564	Inc. 564	8,270	25.17	16.6	8.3	14.7	19.1		145	
F67-563	Inc. 563	8,080	24.51	16.6	5.2	10.7	14.5		151	
Mean		12,940	40.01	16.3	9.0	15.8	20.3		156	
LSD (.05)		1,614	5.51	0.98	8.60	11.10	11.90		15.37	
Coefficient of Variation		8.95	9.88	4.32	68.52	50.48	42.05		7.07	
F value		15.12**	14.81**	3.16**	8.81**	9.35**	10.42**		2.38**	

**Exceeds the 1% point of significance (F=1.53)

VARIETY TEST (Spence 570), SALINAS, CALIFORNIA, 1970

(10 replications of each variety)
(Single-row plots)

Planted: February 9, 1970
Harvested: September 24, 1970

Variety	Description	Acre Yield		Sucrose Percent	Beets/ 100'
		Sugar Pounds	Beets Tons		
813H48	(716H29 x 734) x 713A	13,610	39.80	17.1	113
813H46	(716H29 x 718) x 713A	13,530	39.94	17.0	114
Y904H49	(716H0 x 760) x Y804	13,510	39.32	17.2	111
Y803H4	569H3 x Y603	13,400	38.30	17.5	116
F66-13H11	550H4 x C413	13,360	38.94	17.2	120
Y904H51	(705H24 x 734) x Y804	13,250	38.78	17.1	111
944	YRS 744	13,100	38.78	16.9	107
Y904A,B	YRS Y704	12,850	37.57	17.1	111
Y801	YRS Y601	12,720	36.95	17.2	109
813H44	(705H24 x 714) x 713A	12,710	36.49	17.5	115
910	YRS 610	12,500	35.98	17.4	106
Y803	Inc. Y603	12,460	35.42	17.6	109
664H2	US H6	12,250	35.78	17.1	106
Y904	Inc. Y804	12,160	36.81	16.5	109
F68-413	Inc. 5 YRS US 75 (Inc. F66-13)	12,140	36.67	16.6	114
F66-13	Inc. 5 YRS US 75 (Inc. C413)	12,140	36.07	16.9	109
F68-613	Inc. 7 YRS US 75 (Inc. C613)	12,060	36.71	16.5	112
F69-413	Inc. 5 YRS US 75 (Inc. F66-13)	12,040	36.12	16.7	107
813	Inc. 8 YRS, 2 SS US 75 (Inc. 713A)	11,600	33.29	17.4	111
F69-713	Inc. 7 YRS, 1 SS US 75 (Inc. C713)	11,350	33.62	16.9	106
F66-64	Inc. 264	10,980	32.72	16.8	105
959	Inc. 659 (Inc. US 56/2)	10,820	32.29	16.8	108
868	Inc. F57-68 (US 75)	10,780	31.78	17.0	113
Mean		12,400	36.44	17.1	111
LSD (.05)		786	2.51	0.34	5.54
Coefficient of Variation		7.19	7.81	2.26	5.68
F value		9.65**	7.13**	7.10**	3.61**

**Exceeds the 1% point of significance (F=1.92)

VARIETY TEST (Spence 670), SALINAS, CALIFORNIA, 1970

(10 replications of each variety)
(Two-row plots)

Planted: February 10, 1970
Harvested: September 29, 1970

Variety	Description	Acre Yield		Sucrose Percent	Beets/ 100'
		Sugar Pounds	Beets Tons		
Y804H8	546H3 x Y704	14,260	41.68	17.1	114
F69-613H8	546H3 x C613	13,930	40.90	17.0	112
Y904H4	569H3 x Y804	13,920	41.04	17.0	111
813H8	546H3 x 713A	13,890	40.16	17.3	115
Y904H45	(705H24 x 718) x Y804	13,810	41.40	16.7	115
813H45	(705H24 x 718) x 713A	13,670	39.94	17.1	112
U913H8	546H3 x F68-413 (US H9B)	13,630	40.56	16.8	112
U913H4	569H3 x F68-413 (US H9A)	13,590	40.32	16.9	111
Y904H8	546H3 x Y804	13,580	39.12	17.4	115
F69-813H8	546H3 x C813	13,470	38.94	17.3	113
F69-813H4	569H3 x C813	13,450	39.22	17.2	109
713H4	569H3 x 613A (C713)	13,410	38.60	17.4	111
U813H8	546H3 x F66-13 (US H9B)	13,390	39.26	17.1	116
U813H4	569H3 x F66-13 (US H9A)	13,310	39.36	16.9	110
Y904H50	(705H24 x 705) x Y804	13,240	38.30	17.3	117
F69-613H4	569H3 x C613	13,130	38.96	16.9	110
813H50	(705H24 x 705) x 713A	13,010	37.44	17.4	116
664H4	US H7	12,540	36.98	17.0	101
868H4	569H3 x F57-68	12,210	36.12	16.9	110
Mean		13,440	39.38	17.1	112
LSD (.05)		588	2.01	0.46	4.41
Coefficient of Variation		4.95	5.77	3.06	4.45
F value		5.39**	4.31**	1.73*	5.21**

*Exceeds the 5% point of significance (F=1.68)

**Exceeds the 1% point of significance (F=2.06)

DIPLOID-TRIPLOID COMPARISON TEST (Spence 770), SALINAS, CALIFORNIA, 1970

(10 x 10 Latin square)
(Single-row plots)

Planted: February 10, 1970
Harvested: October 5, 1970

Variety	Description	Acre Yield		Beets Tons	Sucrose Percent	N PPM	Na PPM	K PPM	Imp. Index	Beets/ 100' Number
		Sugar Pounds	Beets Tons							
813TH8	546H3 x 713T	14,760	(45.20) ^{1/}	16.3	629	133	2,072	731	121	
813H8A	546H3 x F66-13	14,220	(42.92)	16.6	729	130	1,965	765	117	
813TH32	716H29 x 713T	14,270	44.50	16.1	684	140	2,382	828	116	
813H32A	716H29 x F66-13	14,660	45.31	16.2	578	153	2,338	755	120	
813TH40	760H29 x 713T	13,860	43.33	(16.0)	627	130	(2,220)	769	115	
813H40A	760H29 x F66-13	13,770	41.50	(16.6)	699	122	(2,000)	749	117	
813TH41	757H32 x 713T	14,290	(45.24)	(15.8)	630	143	2,458	820	115	
813H41A	757H32 x F66-13	13,900	(42.63)	(16.3)	684	159	2,359	816	117	
813TH49	760H33 x 713T	14,420	44.63	16.2	659	150	(2,337)	802	113	
813H49A	760H33 x F66-13	13,850	42.18	16.5	680	124	(2,168)	771	113	
Mean		14,200	43.74	16.3	660	138	2,230	781	116	
SE of Mean		193	0.62	0.15	35	12	49	27		
LSD (.05)		543	1.74	0.41	98	34	139	75	6.14	
Coefficient of Variation		6.64	7.33	3.26	21.98	34.52	10.80	14.75	8.05	
F value		3.29**	5.15**	3.13**	1.61	1.08	12.14**	1.60	1.35	

**Exceeds the 1% point of significance (F=2.67)

^{1/} Means enclosed in brackets are significantly different.

DIPLOID-TRIPLOID COMPARISON TEST (Spence 870), SALINAS, CALIFORNIA, 1970
(Space planted, thinned with long-handled hoe)

(5 replications of each variety)
(Two-row plots)

Planted: April 6, 1970
Harvested: October 7, 1970

Variety	Description	Acre Yield		Sucrose Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest	
		Sugar Pounds	Beets Tons						Count	Number
813TH8	546H3 x 713T	9,290	28.40	1/ (16.4) (17.1)	1,108	175	2,500	1,104	134	134
813H8A	546H3 x F66-13	9,130	26.72		1,198	192	2,282	1,070	156	156
813TH32	716H29 x 713T	8,550	27.04	15.8	786	267	2,782	996	147	147
813H32A	716H29 x F66-13	9,460	29.00	16.3	732	210	2,519	878	179	179
813TH41	757H32 x 713T	9,140	28.74	15.9	721	236	2,767	940	173	173
813H41A	757H32 x F66-13	9,220	28.56	16.2	796	233	2,526	938	230	230
813TH49	760H33 x 713T	9,200	28.38	16.3	844	235	(2,738) (2,145)	995	163	163
813H49A	760H33 x F66-13	9,320	27.98	16.7	935	179		923	237	237
Mean		9,160	28.10	16.3	890	216	2,532	981	Beets	
SE of Mean		248	0.90	0.2	156	26	86	107	per	
LSD (.05)		NS	NS	0.57	NS	NS	250	NS	100'	
Coefficient of Variation		6.06	7.16	2.68	39.23	26.82	7.61	24.50	row	
F value		1.18	0.82	4.40**	1.27	1.57	7.16**	0.51		

**Exceeds the 1% point of significance (F=3.39)

1/ Means enclosed in brackets are significantly different.

VARIETY TEST (Spence 470), SALINAS, CALIFORNIA, 1970
Inoculated with yellows

(10 replications of each variety)
(Single-row plots)

Planted: February 9, 1970
Harvested: September 21, 1970

Variety	Description	Acre Yield			Beets/
		Sugar	Beets	Sucrose	100'
		Pounds	Tons	Percent	Number
944	YRS 744	9,500	29.50	16.2	104
Y904A,B	YRS Y704	9,010	28.14	16.1	108
813H48	(716H29 x 734) x 713A	8,990	28.74	15.7	108
Y904H49	(716H0 x 760) x Y804	8,890	27.99	15.9	109
813H8	546H3 x 713A	8,840	27.46	16.2	117
Y803H4	569H3 x Y603	8,840	27.32	16.3	115
Y904H50	(705H24 x 705) x Y804	8,720	27.08	16.1	114
Y803	Inc. Y603	8,660	26.26	16.5	104
Y904H45	(705H24 x 718) x Y804	8,660	27.59	15.7	111
813H46	(716H29 x 718) x 713A	8,620	27.67	15.6	111
910	YRS 610	8,560	26.67	16.1	102
Y904	Inc. Y804	8,460	26.83	15.8	108
Y804H8	546H3 x Y704	8,450	26.86	15.8	109
F69-613H8	546H3 x C613	8,380	26.29	16.0	115
Y904H8	546H3 x Y804	8,350	26.30	16.0	113
813H45	(705H24 x 718) x 713A	8,340	26.53	15.8	111
813H44	(705H24 x 714) x 713A	8,290	26.26	15.9	114
813	Inc. 8 YRS, 2 SS US 75 (Inc. 713A)	8,210	25.99	15.9	112
813H50	(705H24 x 705) x 713A	8,180	25.00	16.4	113
F68-613	Inc. 7 YRS US 75 (Inc. C613)	8,170	26.49	15.5	110
F66-13H11	550H4 x C413	8,110	25.99	15.6	114
Y904H51	(705H24 x 734) x Y804	8,100	26.00	15.6	109
Y904H4	569H3 x Y804	8,050	25.73	15.7	112
F69-813H8	546H3 x C813	7,870	24.69	16.0	106
Y801	YRS Y601	7,840	25.04	15.7	110
713H4	569H3 x 613A (C713)	7,660	24.34	15.8	108
U913H8	546H3 x F68-413 (US H9B)	7,650	24.37	15.8	112
U813H8	546H3 x F66-13 (US H9B)	7,600	24.40	15.7	114
F69-713	Inc. 7 YRS, 1 SS US 75 (Inc. C713)	7,490	23.48	16.0	106
U913H4	569H3 x F68-413 (US H9A)	7,440	23.96	15.6	103
F69-613H4	569H3 x C613	7,430	23.96	15.6	110
F68-413	Inc. 5 YRS US 75 (Inc. F66-13)	7,420	23.81	15.7	104
F69-813H4	569H3 x C813	7,360	23.41	15.8	106
U813H4	569H3 x F66-13 (US H9A)	7,080	23.21	15.3	111
F69-413	Inc. 5 YRS US 75 (Inc. F66-13)	7,070	22.38	15.8	105
F66-13	Inc. 5 YRS US 75 (Inc. C413)	6,660	21.49	15.5	104
664H4	US H7	5,630	18.47	15.3	105
664H2	US H6	5,530	18.21	15.3	102
959	Inc. 659 (Inc. US 56/2)	5,330	17.29	15.4	108
868H4	569H3 x F57-68	5,320	17.63	15.1	108
F66-64	Inc. 264	4,900	16.32	15.0	99
863	Inc. F57-68 (US 75)	4,380	14.85	14.8	109

Mean	7,720	24.52	15.8	109
LSD (.05)	666	2.10	0.31	7.00
Coefficient of Variation	9.81	9.71	2.27	7.31
F value	25.80**	21.96**	9.68**	2.64**

**Exceeds the 1% point of significance (F=1.64)

Effect of BYV-BWV infection on yield and sucrose percentage
of sugarbeet varieties at Salinas, California, 1970

Variety	Reduction in yield and sucrose			Variety	Reduction in yield and sucrose		
	Sugar	Beets	Pct. pts.		Sugar	Beets	Sucrose
Inoculated vs. one-row variety trial				Inoculated vs. two-row variety trial			
Y904A,B	25.2	25.1	1.0	Y904H50	34.1	29.3	1.2
944	27.5	23.9	0.7	813H8	36.4	31.6	1.1
813	29.2	21.9	1.5	813H50	37.1	33.2	1.0
Y904	30.4	27.1	0.7	Y904H45	37.3	33.4	1.0
Y803	30.5	25.9	1.1	Y904H8	38.5	32.8	1.4
910	31.5	25.9	1.3	813H45	39.0	33.6	1.3
F68-613	32.3	27.8	1.0	F69-613H8	39.8	35.7	1.0
813H48	33.9	27.8	1.4	Y804H8	40.7	35.6	1.3
F69-713	34.0	30.2	0.9	F69-813H8	41.6	36.6	1.3
Y803H4	34.0	28.7	1.2	Y904H4	42.2	37.3	1.3
Y904H49	34.2	28.8	1.3	713H4	42.9	36.9	1.6
813H44	34.8	28.0	1.6	U813H8	43.2	37.9	1.4
813H46	36.3	30.7	1.4	F69-613H4	43.4	38.5	1.3
Y801	38.4	32.2	1.5	U913H8	43.9	39.9	1.0
Y904H51	38.9	33.0	1.5	F69-813H4	45.3	40.3	1.4
F68-413	38.9	35.1	0.9	U913H4	45.3	40.6	1.3
F66-13H11	39.3	33.3	1.6	U813H4	46.8	41.0	1.6
F69-413	41.3	38.0	0.9	664H4	55.1	50.1	1.7
F66-13	45.1	40.4	1.4	868H4	56.4	51.2	1.8
959	50.7	46.5	1.4				
664H2	54.9	49.1	1.8				
F66-64	55.4	50.1	1.8				
868	59.4	53.3	2.2				

Note: The above values were obtained by comparing varietal performances from three adjoining tests (Spence 470, 570, and 670). The performance data for these tests are presented in preceding tables. Spence 470 was inoculated with BYV-BWV. All tests were subsequently sprayed with aphicides to prevent spread of yellows. Percent infection in the inoculated test was very high, but only light infection occurred late in the season on the noninoculated tests and probably caused little damage. However, the apparent damages caused by yellows are probably exaggerated. The inoculated test was centered in an area of the plot field where low soil pH attributed to poor plant growth. Although adjacent to the inoculated test, the noninoculated tests were removed far enough to be only slightly affected by this poor soil condition.

VARIETY x VIRUS TEST (Spence 1070), SALINAS, CALIFORNIA, 1970

8 x 8 Latin Square, split by virus treatments
Two-row plots
Combination of BY and BWY viruses

Planted: April 7, 1970
Inoculated: June 2, 1970
Harvested: October 7, 1970

Variety	Description	Acre Yield ^{1/}			Beets			Beets / 100'		
		Sugar		Rank	Tons	Rank	Sucrose		Number	
		Pounds	Rank				Percent	Rank		
Noninoculated										
Y803	Inc. Y603	7,395a	(1)	(1)	20.90a	(3)	(3)	17.68a	(1)	149
Y904	Inc. Y804	7,310ab	(2)	(2)	21.90a	(1)	(1)	16.66b	(7)	149
US H20	SL(129 x 133) MS x SP6322-0	7,117abc	(3)	(3)	21.44a	(2)	(2)	16.61b	(8)	164
Y801	YRS Y601	6,888abc	(4)	(4)	20.16ab	(4)	(4)	17.11ab	(3)	149
F69-413	Inc. 5 YRS US 75	6,674bcd	(5)	(5)	19.95abc	(5)	(5)	16.75b	(6)	137
813	Inc. 8 YRS, 2 SS US 75	6,457cd	(6)	(6)	18.81bc	(6)	(6)	17.19ab	(2)	146
915	Inc. 215 (US 15)	6,044d	(7)	(7)	17.92c	(8)	(8)	16.86b	(4)	153
868	Inc. F57-68 (US 75)	6,008d	(8)	(8)	17.92c	(7)	(7)	16.78b	(5)	152
Mean		6,736			19.87			16.95		150
VY Inoculated										
Y803	Inc. Y603	5,511a	(1)	(1)	16.57a	(3)	(3)	16.64a	(1)	146
Y904	Inc. Y804	5,224ab	(3)	(3)	16.92a	(1)	(1)	15.43cd	(5)	145
US H20	SL(129 x 133) MS x SP6322-0	3,556c	(6)	(6)	11.78b	(6)	(6)	15.08d	(7)	164
Y801	YRS Y601	4,937ab	(4)	(4)	15.23a	(4)	(4)	16.19ab	(3)	140
F69-413	Inc. 5 YRS US 75	4,777b	(5)	(5)	14.98a	(5)	(5)	15.89bc	(4)	135
813	Inc. 8 YRS, 2 SS US 75	5,508a	(2)	(2)	16.90a	(2)	(2)	16.31ab	(2)	145
915	Inc. 215 (US 15)	3,051c	(8)	(8)	10.18b	(7)	(7)	14.99d	(8)	152
868	Inc. F57-68 (US 75)	3,094c	(7)	(7)	10.17b	(8)	(8)	15.21d	(6)	149
Mean		4,457**			14.09**			15.72**		147**
% Reduction in Yield										
Y803	Inc. Y603	25.5	(2)	(2)	20.7	(2)	(2)	1.04	(4)	
Y904	Inc. Y804	28.5	(5)	(5)	22.7	(3)	(3)	1.23	(5)	
US H20	SL(129 x 133) MS x SP6322-0	50.0	(8)	(8)	45.1	(8)	(8)	1.53	(6)	
Y801	YRS Y601	28.3	(3)	(3)	24.5	(4)	(4)	0.92	(3)	
F69-413	Inc. 5 YRS US 75	28.4	(4)	(4)	24.9	(5)	(5)	0.86	(1)	
813	Inc. 8 YRS, 2 SS US 75	14.7	(1)	(1)	10.2	(1)	(1)	0.88	(2)	
915	Inc. 215 (US 15)	49.5	(7)	(7)	43.2	(7)	(7)	1.87	(8)	
868	Inc. F57-68 (US 75)	48.5	(6)	(6)	43.2	(6)	(6)	1.57	(7)	
Mean		33.8			29.1			1.23		

Pct. Pt. Reduction

^{1/} Means with same letter are not significantly different.

VARIETY x VIRUS TEST (Spence 1070), SALINAS, CALIFORNIA, 1970 continued

8 x 8 Latin Square, split by virus treatments
Two-row plots

Planted: April 7, 1970
Inoculated: June 2, 1970
Harvested: October 7, 1970

Combination of BY and BWV viruses

Variety	Description	NH ₂ -N				Root Na				Impurity			
		ppm	Rank	ppm	Rank	ppm	Rank	ppm	Rank	Index	Rank		
Noninoculated													
Y803	Inc. Y603	623ab	(5)	207abc	(5)	2,178	(2)	701abc	(3)				
Y904	Inc. Y804	610a	(3)	150a	(3)	2,350	(5)	750abcd	(4)				
US H20	SL(129 x 133) MS x SP6322-0	571a	(1)	253c	(7)	1,739	(1)	659a	(1)				
Y801	YRS Y601	613a	(4)	236bc	(6)	2,359	(6)	751abcd	(5)				
F69-413	Inc. 5 YRS US 75	685ab	(7)	145a	(2)	2,431	(8)	802cd	(7)				
813	Inc. 8 YRS, 2 SS US 75	576a	(2)	140a	(1)	2,218	(3)	685ab	(2)				
915	Inc. 215 (US 15)	662ab	(6)	173ab	(4)	2,371	(7)	780bcd	(6)				
868	Inc. F57-68 (US 75)	766b	(8)	261c	(8)	2,304	(4)	855d	(8)				
Mean		638		195		2,244		748					
VY Inoculated													
Y803	Inc. Y603	549a	(1)	264c	(8)	2,046	(2)	693a	(1)				
Y904	Inc. Y804	550a	(2)	196abc	(3)	2,598	(8)	822bc	(4)				
US H20	SL(129 x 133) MS x SP6322-0	950c	(8)	223bc	(5)	1,706	(1)	966de	(7)				
Y801	YRS Y601	665ab	(5)	216bc	(4)	2,370	(4)	824bc	(5)				
F69-413	Inc. 5 YRS US 75	606ab	(4)	165ab	(2)	2,486	(7)	806ab	(3)				
813	Inc. 8 YRS, 2 SS US 75	559a	(3)	130a	(1)	2,305	(3)	724ab	(2)				
915	Inc. 215 (US 15)	716b	(6)	235bc	(6)	2,418	(6)	935cd	(6)				
868	Inc. F57-68 (US 75)	930c	(7)	245c	(7)	2,378	(5)	1,060e	(8)				
Mean		690**		209*		2,288		854**					
Difference													
Y803	Inc. Y603	-74	(2)	57	(7)	-132	(1)	-8	(1)				
Y904	Inc. Y804	-60	(3)	46	(6)	248	(8)	72	(4)				
US H20	SL(129 x 133) MS x SP6322-0	379	(8)	-30	(1)	-33	(2)	307	(8)				
Y801	YRS Y601	52	(5)	-20	(2)	11	(3)	73	(5)				
F69-413	Inc. 5 YRS US 75	-79	(1)	20	(5)	55	(5)	4	(2)				
813	Inc. 8 YRS, 2 SS US 75	-17	(4)	-10	(4)	87	(7)	39	(3)				
915	Inc. 215 (US 15)	54	(6)	62	(8)	47	(4)	155	(6)				
868	Inc. F57-68 (US 75)	164	(7)	-16	(3)	74	(6)	205	(7)				
Mean		52		14		44		106					

VARIETY x VIRUS TEST (Spence 1070), SALINAS, CALIFORNIA, 1970

Levels of significance obtained for main effects and interactions for varieties and virus yellows infections.

Source	df	Gross Sugar	Beet Yield	% Sucrose	Beets/100'	ppm NH ₂ -N	ppm Root Na	ppm Root K	Impurity Index
Varieties	7	**	**	**	**	**	**	**	**
Columns	7	*	NS	**	NS	**	**	NS	**
Rows	7	**	**	**	**	NS	**	**	**
Error A	42								
Virus	1	**	**	**	**	**	*	NS	**
Var x Vir	7	**	**	*	NS	**	*	NS	**
Vir x Col	7	NS	NS	NS	NS	NS	NS	NS	NS
Vir x Row	7	**	**	NS	NS	NS	NS	NS	NS
Error B	42								

Simple correlation coefficients for eight factors from a test with eight varieties with blocks split by virus yellows treatments.

	% Sucrose	Gross Sugar	ppm NH ₂ -N	ppm Na	ppm K	Imp. Index	Beets/100'
Beet Yield - Infected	.60**	.99**	-.53**	-.32**	.12	-.59**	-.08
- Healthy	-.10	.97**	-.08	.06	-.03	-.03	.47**
- Combined	.67**	.99**	-.39**	-.17	.00	-.54**	.19*
% Sucrose - Infected		.71**	-.37**	-.29*	.07	-.56**	-.15
- Healthy		.16	.16	-.16	.14	-.11	-.08
- Combined		.77**	-.26**	-.23**	.02	-.54**	-.01
Gross Sugar- Infected			-.53**	-.33**	.12	-.61**	-.09
- Healthy			-.04	.01	.01	-.06	.44**
- Combined			-.37**	-.19*	.00	-.56**	.17
ppm NH ₂ -N - Infected				.23	-.15	.90**	.40**
- Healthy				.28*	.38**	.88**	.05
- Combined				.25**	.04	.87**	.23**
ppm Na - Infected					-.22	.29*	.09
- Healthy					-.11	.35**	.13
- Combined					-.16	.32**	.10
ppm K - Infected						.21	-.38**
- Healthy						.66**	-.26*
- Combined						.36**	-.33**
Imp. Index - Infected							-.24
- Healthy							-.04
- Combined							.07

* and ** Significantly different from 0 at the 5% and 1% levels, respectively.

VARIETY TESTS, BRAWLEY, CALIFORNIA, 1969-70

Location: U.S. Department of Agriculture, Southwestern Irrigation Field Station.^{1/}

Soil type: Holtville silty clay loam.

Previous crops: Sugarbeets, 1968-69; barley, 1964-68.

Fertilizer used: 210 lbs. per acre 11:48:0, preplant, broadcast before listing.
200 lbs. actual N, as ammonium nitrate, sidedressed October 17, 1969.

Herbicide used: TOK herbicide, at 3 lbs. per acre in 35 gallons of water, was applied after planting.

Planting date: September 22-23, 1969.

Thinning date: October 9-10, 1969 and rethinned October 20, 1969.

Harvest dates: Early harvest - April 28-30, 1970, two tests.
Midseason harvest - June 3-4, 1970, two tests.
Late harvest - July 14, 1970, one test.

Irrigations: Early harvest - 8 irrigations plus 2.22 inches rainfall.
Midseason harvest - 11 irrigations plus 2.22 inches rainfall.
Late harvest - 14 irrigations plus 2.22 inches rainfall.

Diseases and insects: Symptoms of yellows infection first appeared in late January 1970, and reached a moderate level of infection by harvest. Curly top infection was minor. An invasion by salt marsh caterpillars was prevented with an aluminum foil barrier around the test plots. The yield test plots were sprayed three times between September 26 and October 10, 1969, with ethyl parathion at a pound per acre for control of crickets, desert flea beetle, and striped cucumber beetles. Spray applications were made with ethyl methyl parathion (6.3) at rates of a pound per acre alone and combined with phosdrin at 4 oz. per acre for control of cabbage loopers and beet armyworm, respectively. These applications were all by aircraft. Kelthane, at a pound per acre, was applied May 12, 1970, to control spider mites in the intermediate and late season harvested tests.

Experimental design: All yield tests were of randomized block design with 10 replications each. All plot rows were 45 feet long. Rows were spaced 30 inches apart.

Sugar analysis: From two ten-beet samples per plot for all tests by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed by the U.S. Agricultural Research Station, Salinas, California. Early harvest test data were analyzed at Salinas, California. Intermediate and late season test data were analyzed by K. D. Beatty.

^{1/} Test plot under the supervision of K. D. Beatty at the Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1970

(10 replications of each variety)
(Two-row plots)

Planted: September 24, 1969
Harvested: April 28, 1970

Variety	Description	Acre Yield		Sucrose	Bolting	Harvest
		Sugar	Beets			
		Pounds	Tons	Percent	Percent	Count
						Number
813H46	(716H29 x 718) x 713A	9,130	29.88	15.3	0.1	139
813H45	(705H25 x 718) x 713A	8,710	27.80	15.7	0.3	139
U813H4	US H9A	8,570	27.45	15.7	0.1	141
913H4	569H3 x C813	8,500	26.82	15.9	0.1	140
Y904H51	(705H24 x 734) x Y904	8,410	27.75	15.2	1.7	138
Y904H4	569H3 x Y904	8,370	26.30	15.9	0.0	141
U813H8	US H9B	8,300	26.57	15.6	0.2	143
913H8	546H3 x C813	8,260	26.33	15.7	0.1	141
Y904H49	(716H0 x 760) x Y904	8,230	26.34	15.6	0.6	138
Y904H45	(705H25 x 718) x Y904	8,230	27.49	15.0	0.6	143
813H44	(705H24 x 714) x 713A	8,140	25.86	15.8	0.2	136
813H50	(705H24 x 705) x 713A	8,080	25.22	15.7	0.1	142
Y904H8	546H3 x Y904	8,010	25.85	15.5	0.3	141
664H8	US H7A	7,930	24.82	16.0	0.1	146
Y904H50	(705H24 x 705) x Y904	7,900	25.81	15.3	0.8	139
664H4	US H7	7,780	24.35	16.0	0.0	148
9714H46	(716H29 x 718) x 9714	7,510	23.78	15.8	0.0	136
868H4	569H3 x 868 (US 75)	7,480	23.85	15.7	0.0	138
Mean		8,200	26.24	15.6	--	Beets
LSD (.05)		441	0.98	0.66	--	per
Coefficient of Variation		6.09	4.21	4.77	--	100'
F value		6.68**	19.48**	NS	--	row

**Exceeds the 1% point of significance (F=2.12)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1970

(10 replications of each variety)
(Two-row plots)

Planted: September 25, 1969
Harvested: April 30, 1970

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
Y904	Inc. Y804	7,940	26.57	15.0	2.6	133
F68-613	Inc. 513	7,830	26.67	14.8	0.8	135
813	YR, SS, 613A	7,780	25.34	15.4	0.4	141
944	Inc. (330 x 234)	7,760	25.70	15.1	0.4	128
F68-413	Inc. F66-13	7,700	26.14	14.7	0.5	139
Y904A	Inc. Y704	7,650	25.29	15.2	2.1	137
F69-713	Inc. 713	7,370	24.76	15.0	1.8	142
F66-64	Inc. 264	7,300	24.33	15.1	0.1	139
814	Imp. Val. sel. fr. 713	7,280	25.35	14.4	1.5	141
915	Inc. US 15	6,960	22.76	15.3	0.0	140
959	Inc. US 56/2	6,760	21.66	15.7	0.3	138
868	Inc. F57-68 (US 75)	6,410	21.77	14.7	0.0	135
Mean		7,400	24.7	15.0	--	Beets
LSD (.05)		394	1.10	0.49	--	per
Coefficient of Variation		6.01	5.01	3.68	--	100'
F value		11.55**	19.84**	3.84**	--	row

**Exceeds the 1% point of significance (F=2.43)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1970

(10 replications of each variety)
(Two-row plots)

Planted: September 24, 1969
Harvested: June 3, 1970

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
813H46	(716H29 x 718) x 713A	12,770	35.81	17.9	0.9	148
Y904H45	(705H25 x 718) x Y904	12,260	34.44	17.8	3.6	146
813H45	(705H25 x 718) x 713A	12,180	34.05	17.9	1.2	141
Y904H4	569H3 x Y904	12,010	33.23	18.1	1.9	144
913H8	546H3 x C813	11,940	32.81	18.3	1.8	150
Y904H8	546H3 x Y904	11,930	32.89	18.2	2.7	145
U813H8	US H9B	11,830	32.91	18.0	0.8	148
913H4	569H3 x C813	11,810	32.58	18.2	0.4	150
813H50	(705H24 x 705) x 713A	11,670	32.48	18.0	2.2	148
U813H4	US H9A	11,640	32.88	17.8	0.6	148
Y904H50	(705H24 x 705) x Y904	11,510	31.99	18.0	6.2	146
664H8	US H7A	10,890	30.24	18.1	0.5	145
664H4	US H7	10,520	29.07	18.1	0.1	146
868H4	569H3 x 868 (US 75)	10,060	27.84	18.1	0.5	144
Mean		11,640	32.37	18.0	1.95	Beets
LSD (0.05)		436	1.41	NS	0.1	per
Coefficient of Variation (%)		4.22	4.93	3.0	44.30	100'
F value		**21.12	17.15**	NS	19.23**	row

**Exceeds the 1% point of significance (F = 2.34)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1970

(10 replications of each variety)
(Single-row plots)

Planted: September 25, 1969
Harvested: June 4, 1970

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest
		Sugar	Beets			Count
		Pounds	Tons			Number
F68-413	Inc. F66-13	11,330	32.16	17.8	5.2	150
Y904	Inc. Y804	11,190	31.69	17.8	19.5	145
(Spence)						
944	Inc. (330 x 234)	10,980	30.63	18.0	6.9	143
F69-713	Inc. 713	10,770	30.46	17.9	6.8	147
F66-13	Inc. 413	10,740	30.13	17.9	7.2	155
F68-613	Inc. 513	10,580	30.06	17.7	6.4	145
Y904A	Inc. Y704	10,540	30.19	17.6	17.7	146
F66-64	Inc. 264	10,330	29.10	17.8	0.8	146
813(Ore)	YR, SS, 613A	9,860	27.69	17.9	2.2	151
959	US 56/2	9,720	27.76	17.6	1.4	145
915	US 15	9,700	26.97	18.0	3.9	144
868	US 75	8,870	25.64	17.4	0.9	147
Mean		10,386	29.37	17.8	6.59	Beets
LSD (0.05)		714	2.00	0.34	1.7	per
Coefficient of variation (%)		7.73	7.67	2.17	39.63	100'
F value		8.03**	7.69**	2.50	41.43	row

**Exceeds the 1% point of significance (2.48)

VARIETY TEST, BRAWLEY - 1970

(10 replications of each variety)
(Single-row, 30" bed plots)

Planted: September 24, 1969
Harvested: July 14, 1970

Variety	Description	Acre Yield		Sucrose Percent	Harvest		Crown Rot Percent
		Sugar Pounds	Beets Tons		Count Number	Bolting Percent	
813H45	(705H25 x 718) x 713A	12,870	38.84	16.63	149	1.7	0.6
Y904H4	569H3 x Y904	12,610	37.61	16.84	152	1.9	0.3
913H8	546H3 x C813	12,320	36.90	16.76	156	1.6	0.1
U813H8	US H9B	12,300	37.27	16.52	161	1.2	0.1
Y904H8	546H3 x Y904	12,260	36.86	16.68	149	4.8	0.5
Y904H50	(705H24 x 705) x Y904	11,990	36.31	16.54	145	7.0	0.2
913H4	569H3 x C813	11,810	35.17	16.86	158	0.6	0.4
U813H4	US H9A	11,760	35.00	16.81	159	1.4	0.0
813H50	(705H24 x 705) x 713A	11,510	34.51	16.73	154	2.7	1.6
664H8	US H7A	10,900	33.97	16.08	157	0.8	0.0
664H4	US H7	10,590	32.97	16.13	157	0.7	0.5
868H4	569H3 x 868 (US 75)	10,140	31.51	16.14	153	0.3	0.1
Mean		11,760	35.58	16.56	Beets	2.0	0.38
LSD (0.05)		577	1.99	0.39	Per	1.8	
Coefficient of Variation (%)		5.51	6.28	2.64	100'	99.37	
F Value		16.57**	10.93**	4.34**	Row	9.39**	

**Exceeds the 1% point of significance (2.48).

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1970

Fall Harvest

by American Crystal Sugar Company

Variety	Lbs. Sugar Per Acre	Tons Per Acre	Percent Sucrose	Impurity Index	Sodium	Potassium	Amino Nitrogen
US H9A	6043	19.37	15.6	288	490	813	67
US H9B	6911	22.44	15.4	274	452	747	82
Y 904 H8	6951	22.28	15.6	249	473	722	43
Y 904 H45	6927	22.06	15.7	286	480	758	68
Y 904 H50	6889	22.08	15.6	271	539	750	44
813 H8	5710	18.54	15.4	254	490	654	57
813 H45	5912	18.95	15.6	301	545	830	68
813 H47	6231	20.23	15.4	289	556	751	66
813 H50	5946	19.82	15.0	303	567	735	70
813 TH32	6599	22.60	14.6	368	506	1042	94
813 TH40	6489	21.63	15.0	301	489	867	59
F66-13 H11	6336	21.12	15.0	274	597	659	54
64-208 x 66-569 H3	6222	18.97	16.4	291	572	820	70
ACS Hybrid S-9730	6315	19.86	15.9	254	474	636	76
ACS Hybrid S-9735	8330	26.53	15.7	267	514	763	54
ACS Hybrid S-9733	7560	23.48	16.1	262	484	736	69
ACS Hybrid S-9734	8198	26.11	15.7	334	633	836	93
ACS Hybrid S-9724	6836	21.91	15.6	292	537	769	77
General Mean	6680	21.55	15.5	287	522	772	67

Randomized Block Design, 2 Row Plots
18 Entries, 6 Replications

Date Planted: March 24, 1970

Date Harvested: August 25 to 27, 1970

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY - 1970

TEST AREAS:		Spreckels, California				Spreckels, Calif.				King City, Calif.				Greenfield, Calif.			
Variety	Description	Sugar T/Ac.	Beets T/Ac.	% Sugar	Bolting %	Sugar T/Ac.	Beets T/Ac.	% Sugar		Sugar T/Ac.	Beets T/Ac.	% Sugar		Sugar T/Ac.	Beets T/Ac.	% Sugar	
US H9A	569H3 x C413	6.061	46.23	13.3	4.81	6.580	49.25	13.4		6.111	39.06	15.7		6.231	45.08	13.8	
US H9B	546H3 x C413	6.190	47.78	13.1	4.46	5.961	46.13	13.1		5.824	36.91	15.8		6.000	43.45	13.8	
C613H4	569H3 x C613	5.641	45.63	12.5	3.40	6.096	46.68	13.2									
C613H8	546H3 x C613	5.550	43.21	13.1	4.42	6.049	45.55	13.5						6.079	43.74	14.0	
C813H4	569H3 x C813	5.650	42.96	13.4	4.36					5.787	36.42	15.9		5.767	42.07	13.7	
C813H8	546H3 x C813	5.820	44.32	13.2	3.42												
GENERAL MEAN		5.931	45.69	13.1	3.51	5.984	44.90	13.5		5.936	37.18	16.0		6.061	43.57	13.9	
LSD @ P = .05		0.557	3.48	NS		0.498	3.08	0.7		NS	NS	NS		NS	NS	NS	
LSD @ P = .01		0.636	3.97	NS		0.665	4.11	1.0		NS	NS	NS		NS	NS	NS	
SE of Mean		0.199	1.240	0.298		0.175	1.087	0.272		0.196	1.084	0.227		0.100	2.230	0.201	
SE in % of Mean		3.36	2.71	2.27		2.92	2.42	2.05		3.30	2.92	1.42		1.66	5.12	1.45	
# Var. in Test		16				8				8				8			
Planting Date		December 16, 1969				December 16, 1969				December 18, 1969				February 18, 1970			
Harvest Date		September 9, 1970				September 8, 1970				October 9, 1970				October 9, 1970			

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY - 1970

TEST AREAS:

V a r i e t y	Description	Spreckels, California				Mendota				Mendota				Mendota			
		Sugar T/Ac.	Beets T/Ac.	% Sugar	% Bolting	Sugar T/Ac.	Beets T/Ac.	% Sugar	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	% Sugar
US H9A	569H3 x C413	7.213	49.97	14.4	5.27					5.270	36.09	14.6		4.512	35.53	12.7	
US H9B	546H3 x C413	6.786	48.42	14.0	7.41					4.890	33.76	14.5		4.258	34.33	12.4	
C613H4	569H3 x C613									5.189	35.95	14.5					
C613H8	546H3 x C613																
C813H4	569H3 x C813									5.276	35.23	15.0		4.483	35.58	12.6	
C813H8	546H3 x C813									5.209	35.62	14.7					
C813TH32	7716H29 x C713T	6.451	50.08	12.9	3.12									3.951	24.66	16.0	
C813TH40	7760H29 x C713T	6.054	46.07	13.1	10.44									4.187	26.67	15.8	
Y904H4	569H3 x Y804	6.852	50.45	13.8	4.00									4.480	27.37	16.4	
Y904H8	546H3 x Y804	7.104	50.38	14.1	4.07									4.639	28.85	16.1	
Y904H45	7718H31 x Y804	6.291	46.57	13.4	5.69									4.318	26.86	16.1	
Y904H50	7705H30 x Y804	6.152	44.46	13.9	10.79									4.616	27.21	16.9	
US H7	569H3 x C663													4.273	26.79	16.0	
GENERAL MEAN		6.973	48.78	14.3	5.29					5.223	35.64	14.7		4.373	34.98	12.5	
LSD @ P = .05		0.507	3.16	0.6						NS	NS	NS		0.707	NS	0.99	
= .01		0.670	4.18	0.9						NS	NS	NS		NS	NS	NS	
SE of Mean		0.181	1.128	0.234						0.188	1.12	1.88		0.248	1.98	0.35	
SE in % of Mean		2.60	2.31	1.64						3.59	3.14	12.79		5.68	5.65	2.79	
# Var. in Test.			18								8				8		
Planting Date			December 16, 1969								February 26, 1970				March 18, 1970		
Harvest Date			September 4, 1970								October 1, 1970				September 29, 1970		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY - 1970

TEST AREAS:

Variety	Description	Chandler, Arizona		
		Sugar T/Ac.	Beets T/Ac.	% Sugar
US H9A	569H3 x C413	3.031	21.68	14.0
US H9A	" x "	3.004	21.38	14.1
US H9B	546H3 x C413	2.869	20.22	14.2
US H9B	" x "	2.961	21.54	13.7
C813H4	569H3 x C813	3.001	21.22	14.1
C813H4	" x "	2.808	20.20	14.0

T = Thimet under seed
U = No Thimet

GENERAL MEAN

2.984 21.26 14.0

LSD @ P = .05
= .01

NS NS NS
NS NS NS

SE of Mean
SE in % of Mean

0.201 1.48 0.20
6.74 6.96 1.44

Var. in Test

8 Varieties (16 Treatments)

Planting Date
Harvest Date

October 10, 1969
July 11, 1970

VARIETY TEST, SALINAS, CALIFORNIA, 1970

(10 replications of each variety)		By Union Sugar Division			
Variety	Description	Acre Yield		Sucrose	Harvest
		Sugar	Beets		
		Pounds	Tons	Percent	Count
					Number
813TH40	760H29 x 713T	7,240	25.60	14.1	103
813TH41	757H32 x 713T	7,140	24.86	14.3	104
Y904H8	546H3 x Y804	6,720	22.81	14.7	105
813TH32	716H29 x 713T	6,590	22.95	14.3	95
Y904H50	705H30 x Y804	6,470	22.04	14.6	111
U813H4	US H9A	6,430	21.78	14.8	119
664H8	US H7A	6,380	21.23	15.0	114
U813H8	US H9B	6,310	21.79	14.4	112
813H45	718H31 x 713A	6,280	21.37	14.5	102
F69-613H8	546H3 x 613	6,190	21.35	14.5	107
F69-813H8	546H3 x 813	6,090	21.31	14.3	116
813H50	705H30 x 713A	6,050	20.80	14.5	107
Y904H45	718H31 x Y604	5,990	20.82	14.3	109
F69-613H4	569H3 x 613	5,800	19.83	14.6	106
F69-813H4	569H3 x 813	5,680	19.31	14.6	108
Y904H4	569H3 x Y804	5,570	18.96	14.6	106
Mean		6,310	21.68	14.5	Beets
LSD (.05)		920	2.96	0.38	per
Coefficient of Variation		16.48	15.44	2.99	100'
F value		2.02*	2.80**	2.64**	row

*Exceeds the 5% point of significance (F=1.74)

**Exceeds the 1% point of significance (F=2.19)

Remarks: A yield test of 16 varieties in a randomized block design was included in a 93 acre field of sugarbeets on the Elmer Abeloe Ranch, Salinas, California. Plots 60 feet long were planted on double-row beds with 40-inch centers. A preplant herbicide treatment of 52 ounces of Tillam in 45 gallons of water per acre was incorporated in 22-inch wide strips on the beds. The test plot was planted April 1, 1970, and thinned May 18, 1970. A post-emergence application of Pyramin 80 W at 2.5 lbs. per acre plus ~~summer~~ oil at a quart per acre was made following thinning. Cutworms were controlled with an application of Nulox 3 bait. The field was sprinkler irrigated at 15-day intervals from about May 1 until September 15. The total fertilizer use consisted of 225 lbs. of actual N and 200 lbs. of P, as P₂O₅, applied as preplant and in two side-dress applications. The test plot was harvested October 21-22, 1970. Sugar analyses were made at the United States Agricultural Research Station, Salinas, California. Test design, seed and analysis of results were supplied by the U.S. Research Station.

Virus diseases were minor but nematode damage was evident in scattered areas throughout the field. The 1970 herbicide applications were generally not effective for control of weeds. However, good weed control was obtained in a small area of the field where X-77 sticker, carried over from 1969 supplies, was included in the Pyramin and oil spray mixture. A 5½ inch seed spacing produced good stands of beets where cutworms were not a problem. The 15-day irrigation cycle caused moisture stresses during 1970 and reduced the yield. The field averaged 19.71 T/A with 16.0 percent sucrose.

VARIETY TEST, SANTA MARIA, CALIFORNIA, 1970

(8 replications of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar Pounds	Beets Tons		
813H4	569H3 x 713A	12,740	35.34	18.0	162
868H4	569H3 x F57-68	12,480	35.87	17.4	169
664H4	US H7	12,400	34.24	18.1	168
U813H4	US H9A	12,380	35.36	17.5	163
U813H8	US H9B	12,370	35.04	17.6	173
S-301-H8	569H3 x A6201	11,560	32.23	17.9	165
F68-413	Inc. 5 YRS US 75	10,900	31.11	17.5	162
813	Inc. 8 YRS, 2 SS US 75	10,110	28.66	17.6	154
Mean		11,870	33.48	17.7	Beets
LSD (.05)		1,081	2.93	0.40	per
Coefficient of Variation		14.29	12.93	3.44	100'
F value		6.06**	6.29**	3.33**	row

**Exceeds the 1% point of significance (F=3.01)

Remarks: A yield test in an 8 x 8 latin square design was included in a field of sugarbeets on the Owen Rice Ranch, Santa Maria, California. The soil class was a sandy loam and previous crops were: chile peppers, 1967; green beans, 1968; and potatoes, 1969. Plots 60 feet long were planted on double-row beds with 40-inch centers. The test was planted November 21, 1969, and thinned February 2, 1970. The field was irrigated nine times by furrow. Fertilizer use totaled 175 lbs. of N, 60 lbs. of P₂O₅, and 60 lbs. of K₂O per acre applied as preplant and as a side-dressing. The test plot was harvested August 17, 1970. Sugar analyses were made by Union Sugar Division, Betteravia, California. Test design, seed and analysis of results were supplied by the United States Agricultural Research Station, Salinas, California.

Virus diseases were minor. Rootknot nematode infestation was moderately heavy in the test plot area. No herbicides or insecticides were used.

VARIETY TEST, CALIPATRIA, CALIFORNIA - 1970

William Young
(8 replications each variety)
(Double row, 40" beds, single bed plots)

Union Sugar Division Cooperating
Planted October 15, 1969
Harvested July 8, 1970

Variety	Description	Acre Yield		Sucrose	Harvest	Crown
		Sugar	Roots		Count	Rot
		Pounds	Tons	Percent	Number	Percent
913H4	569H3 x C813	11,410	38.84	14.67	113	1.8
U813H4	US H9A	11,260	38.31	14.69	115	1.1
Y904H4	569H3 x Y904	11,200	39.56	14.14	110	4.2
U813H8	US H9B	11,180	38.72	14.41	118	1.8
913H8	546H3 x C813	10,980	37.40	14.68	112	0.9
813TH49	(716H0 x 760) x 813T	10,940	39.54	13.82	109	3.0
813H45	(705H25 x 718) x 713A	10,850	38.14	14.21	112	2.4
664H4	US H7	9,180	33.62	13.66	110	2.4
General Mean of						
All Varieties		10,880	38.02	14.29	Beets	2.2
Significant Difference (0.05)		708	2.22	0.49	Per	1.7
Coefficient of Variation (%)		6.44	5.77	3.43	100'	75.00
F Value		8.38**	6.09**	5.29**	Row	3.34**

**Exceeds the 1% point of significance (F=3.12).

Remarks: A yield test in an 8 x 8 latin square design was included in a field of sugarbeets located at Canal H, gate 4, William Young Ranch. The soil class was a sandy loam and previous crops were sugarbeets, 1967-68 and 1968-69. A preplant herbicide treatment of 4 lbs. Roneet per acre was incorporated in a band on the beds. Plots 60 feet long were planted on double-row beds with 40-inch centers. The test was planted October 15, 1969, and thinned October 31, 1969. Kelthane applied in early May 1970 controlled a spider mite infestation. Symptoms of yellows infection first appeared in February and eventually reached a moderate level of infection. Curly top infection was minor. Irrigation was by furrow. Fertilizer use totaled 265 lbs. per acre N and 110 lbs. per acre P, as P₂O₅, applied as preplant and in two sidedress applications after thinning. The test was harvested July 8, 1970. The field in which the yield test was located yielded 27.1 T.P.A. with 14.2 percent sucrose.

Sucrose determinations were made by Union Sugar Division, Imperial Valley Tare Laboratory, Imperial, California. Experimental design and seed were supplied by U.S. Agricultural Research Station, Salinas, California. Test was planted, observed throughout season, and harvested by K. D. Beatty, Southwestern Irrigation Field Station, Brawley, California, in cooperation with Union Sugar Division. Results were analyzed by K. D. Beatty.

BREEDING FOR NEMATODE RESISTANCE

Efforts to select for resistance to the sugarbeet nematode (Heterodera schachtii) within the cultivated sugarbeet have been underway at the U.S. Agricultural Research Station, Salinas, California, for over 15 years. Some improvement has been demonstrated in the performance of the selections, but opportunities for developing resistant varieties from within Beta vulgaris are not promising. Recently, some very significant progress has been made in transferring resistance from the wild Beta procumbens species to the cultivated beet. Beginning with the 1970 season, most selection work within Beta vulgaris has been discontinued and major emphasis is being placed on interspecific hybridization. (Statement by J. S. McFarlane)

Summary of Nematode Resistance Breeding Research 1966-70

D. L. Doney and E. D. Whitney

Introduction

Field trials for the years 1963, 1964, and 1965 indicated that some of the nematode resistant selections which had been made at Salinas were consistently better than their parents when grown in nematode infested soil. Plants had been selected in the greenhouse following two to three successive tests in flats of nematode infested soil. Plants were rated on the basis of vigor and number of observed nematodes on the roots. Those with few nematodes and high vigor were saved for seed increase. The mass selection system of breeding was used almost exclusively.

Many lines, introductions, and cultivars had been screened for immunity with no evidence of complete immunity except in the wild Beta patellares section. Breeding for immunity from the wild immune species has been under the direction of Dr. Helen Savitsky.

A review of the ratings and a comparison of the first, second, and third successive selection tests indicated that little progress was being made with this technique. One of the difficulties was associated with the presence of pathogens other than nematodes in the soil used for testing. In a trial conducted in the fall of 1965 with two different nematode infested soils, the effect of other soil pathogens seemed to be confounding potential progress. One of these soils was fairly clean of soil fungi, whereas the other soil was heavily infested with soil fungi. It appeared that progress could be made in the cleaner soil. Earlier workers had reported similar results. Therefore, the first effort was to develop a testing technique in which beets could be uniformly infected with nematodes free of any contaminating root-rotting pathogens.

Hatching technique

Many nematode cysts were found to contain pathogenic fungi, so attempts were made to hatch and surface sterilize larvae in large enough quantities for a breeding program. Under the direction of Dr. E. D. Whitney, a technique was developed in which large quantities of surface sterilized nematode larvae could be obtained with a minimum amount of effort. This work is reported in Phytopathology 60: 1191-1194.

Inoculation technique

Aluminum cylinders were used extensively in the early investigations, but two problems arose. First, once the cylinder was opened, roots and cysts were sufficiently disturbed that repotting was always necessary after observation of the soil ball. The second problem was that there was no way of determining the best time for observation and counting. The use of clear plastic vials overcame these two objections. Thereafter, most of the testing was done in 85 and 185 ml plastic vials.

Following the development of a method for producing surface sterilized larvae, a number of tests with plastic vials were conducted to determine the best inoculation and testing technique. Following are some of the methods employed in this survey:

1. Test - Counting of white females at soil-vial interface versus total nematode count. Conclusion - A very high correlation exists between total nematode count and white females at the soil-vial interface. This counting procedure was adopted.

2. Test - Soil versus sand. Conclusion - The infection rate was slightly higher in sand, but easier counting of white females in soil resulted in the use of a dark, loamy, sandy soil.

3. Test - Inoculation position, i.e. suspensions of larvae were placed (1) around the soil-vial interface, (2) around the plant stem, (3) near the roots 3/4" below the soil surface, and (4) equally over soil surface followed by light watering. Conclusion - Best results were achieved by adding the larvae suspension equally over the soil surface followed by a light watering of about 10 ml of H₂O.

4. Test - Plant manipulation - with treatments as follows:

- (1) Inoculate in transplanting hole prior to transplanting.
- (2) Inoculation of untransplanted plants.
- (3) Inoculation of seedlings prior to their being transplanted.
- (4) Tap roots trimmed at transplanting time to induce more uniform fibrous root systems.
- (5) Foliage trimmed prior to transplanting (Note: earlier reports on other crop plants indicated this would increase infection rate, but we found no such effect).

- (6) Inoculation time after transplanting, i.e. immediately, 1 week, 2 weeks, and 3 weeks after transplanting.
- (7) Repeated inoculation, i.e. the inoculum was divided into 1, 2, 3, and 4 portions to be added on successive days.

Conclusion: The most uniform and highest infection rate was achieved by transplanting seedlings into dark, sandy soil in plastic vials and inoculating 2-3 weeks after transplanting, or when good root growth appeared around the soil-vial interface with 2-3 repeated inoculations on successive days.

5. Test - Fibrous root weights were correlated with nematode infection rate 1 week after inoculation and 4 weeks after inoculation. Conclusion - There was very little relationship between fibrous root weight and infection rate, but in other tests small correlations were found between the observed roots at the soil-vial interface at inoculation time and later nematode counts. This was largely caused by plants with very few roots at inoculation time.

6. Test - Repeated tests. Plants were repotted and reinoculated in 2 and 3 successive tests on the same plants. Correlations were conducted on nematode counts and root weights with successive tests. Conclusion: There was little relationship with nematode counts in successive tests on the same plants. Likewise, correlations were small between root weight and nematode counts on successive tests.

Environmental variance

In the early testing, large environmental variances were observed; therefore, homozygous material was included in most tests to measure the environmental error and gain estimates of the genetic variances. The homozygous lines used were uniform hybrids, inbreds, and Dr. B. L. Hammond's doubled haploid.

Early testing for infection rate indicated little or no difference between selections and parents, which suggests that all differences were largely environmental. Factors influencing this large experimental error included inoculation techniques, temperature, moisture, and soil fertility.

Many different inoculation techniques were attempted, many of which are discussed above. One additional satisfactory technique was inoculation with increasing numbers of larvae for each of 5 successive weeks. Plants were not harvested for about 4 months after inoculations had begun. This allowed time for about 3 nematode life cycles, after which the nematode population in the soil was determined.

Greenhouse temperatures were maintained between 70°F and 80°F for best nematode development. In some tests, moistened sand was added around the pots or vials to prevent heat build-up on sunny days. In

addition, the greenhouses were whitewashed during the summer months. Variations in soil moisture can be critical in nematode development. Several types of watering schemes to maintain adequate and equal soil moisture were studied. Soil moisture tensiometers were used to measure moisture tension in these studies. The most satisfactory method was to bring the soil moisture up to field capacity when the soil surface became dry. This prevented wilting, and puddling or over-watering was reduced to a minimum.

Two separate trials were conducted on soil fertility in relation to nematode population build-up and nematode effect. Different sources of nitrogen and different levels of fertility were studied. It appeared as if different sources of nitrogen had an effect on sugarbeet growth, but no effect on the nematode population build-up. However, higher nematode populations developed in low fertility treatments than in high fertility treatments. There was a larger reduction in plant growth due to nematodes in the low fertility treatments compared to the higher fertility treatments.

Methods of selection

In view of the slow progress of earlier workers and the fact that variation in the presently used conventional methods is largely environmental, several methods of selection were pursued.

1. Nematode counts.--A common practice that had been successful with other crop plants was to count the white females on the soil ball periphery. A large number of nematode selections and their parents were evaluated in this way. Nematode selections from several breeding stations around the world were included in the tests. Many heterozygous lines and plant introductions were also screened for nematode resistance. In all tests a uniform hybrid or inbred was included for an estimate of the environmental variance. Much of this testing is reported in the Journal of the American Society of Sugar Beet Technologists 15: 546-552. There were no consistent differences between any of the lines tested or between the selections and their parents. The genetic variances were so small that genetic deviates could not be detected. Thus, any selection in this material based on white female counts would be largely environmental with a very small probability of progress. Therefore, this method of selection was discontinued.

2. Sprangled or forked roots.--Some reports indicated that nematode infection induces sprangled or forked roots in the sugarbeet. Several attempts were made to measure nematode influence or incidence of forked or sprangled roots, as well as to make selections that resisted this nematode-induced phenomena. When surface sterilized larvae were used as inoculum in medium to high inoculum levels, very little sprangling occurred. Therefore, it was impossible to make selections for this character. More sprangling appeared when nematodes and certain pathogenic soil fungi were present in the soil together.

3. Coarse roots.--It was noted that plants heavily infested with nematodes produce coarser fibrous roots than normal. Several selections were made for differences in fibrous root texture under heavy nematode infestations. Seed was obtained from these selections and tested in the field. There was no difference in these field trials between the fine and coarse fibrous root selections.

4. Amino acids.--Several tests were conducted to measure the effect of nematode invasion on the free amino acids in the fibrous roots of sugarbeets. Significantly higher concentrations of aspartic acid, glutamic acid, and glutamine were observed in nematode infected sugarbeet plants, but there was no change in the concentrations of these amino acids in nematode infected Beta patellaris plants (a wild immune species). This work was reported in Phytopathology 60: 1727-1729. Some genetic variation for the concentration of these amino acids in nematode infected plants was also observed. A number of genetic deviates were selected for testing of this technique. Seed was produced from these selections and the resultant seed planted in a nematode field trial for testing. No differences in yield or percent sucrose were obtained between high and low amino acid concentration selections. Lack of seed eliminated any further field testing of this material.

5. Stunting of seedlings.--Under heavy nematode infestations sugarbeet seedlings can be killed or severely stunted. A screening system based on this early nematode effect was tested. As soon as emergence occurred each seedling received a series of 3 inoculations of 5,000 nematode larvae each, 12 hours apart. This severely stunted and killed many seedlings. Selections were made of vigorous surviving seedlings. However, after several large scale tests, no consistent results or genotypic variances were evident. Therefore, this testing system was discontinued.

6. Laboratory tests.--(a) Sterilized seed was germinated in water agar and inoculated with surface sterilized larvae. This allowed closer examination of infection and plant reaction to infection. Difficulties were encountered in obtaining good infection in water agar so this method was not pursued any further. (b) Upon entry into the root, nematode larvae release certain macerating enzymes that break down the cell wall and cell tissue. To measure the effect of these macerating enzymes on different sugarbeet selections, beet discs were placed in solutions of homogenized larvae. Some differences were observed in their effect on discs of B. vulgaris and B. patellaris, but these differences were difficult to measure and of insufficient magnitude to be useful as a selection criterion.

7. Root yield. Greenhouse.--A number of trials were conducted in the greenhouse in an effort to detect genetic deviates for root yield under controlled greenhouse conditions. In all trials, homozygous lines were included for estimates of environmental variances. Infection was achieved by inoculating with known amounts of surface sterilized larvae and allowing 2-3 nematode cycles to occur (about 4 months). Large

nematode populations developed in these trials. Several methods were employed to control or reduce the environmental error, such as size of container, moisture, and temperature. One trial was conducted in temperature controlled chambers where the soil temperature was maintained between 70°F and 75°F.

Little genetic variance was obtained in most of these tests. In two trials, genetic deviates were observed and selected for seed increase. Seed from these selections were planted with their parents in a replicated nematode infested field trial in 1968. Small insignificant differences were obtained between the selections and their parents.

8. Field selection.--Field selection for yield was in replicated space planted trials. Uniform inoculation was achieved by placing one liter of uniformly mixed nematode infested soil in holes spaced two feet apart. The nematode infested soil contained about 30 viable cysts per 100 grams of soil. Seed was planted in the center of the nematode soil. Plants were thinned to one plant per 2-foot spacing when they were about 4-weeks old. Heavy nematode infection caused some seedling mortality prior to thinning. In all trials a uniform hybrid and a homozygous inbred were included for estimates of environmental error. Each trial also included non-infested plots. At harvest time, each root was numbered, weighed, and analyzed for percent sucrose.

From these data we were able to estimate the nematode damage, the environmental variance, and the genetic variances for each line. Large significant genetic variances were obtained in several lines. By placing probabilities on each beet for superiority or inferiority in root yield, percent sucrose, and total sucrose, we were able to select genetically superior roots in each of these three categories.

These field selection trials were conducted in 1968 and 1969. Seed from the selections made in 1968 will be tested for genetic progress in field trials in 1970.

9. Field testing.--A great deal of difficulty was encountered in obtaining field plots uniformly infested with nematodes. Large differences in numbers of viable cysts occurred within blocks and between years. This made good field testing difficult.

In the field selection technique mentioned above, uniformly infested soil was added to overcome this micro-location variation in nematode population. In other trials, nematode infested soil was added uniformly in the center of each row prior to planting.

Farming practices also affect the nematode distribution in the soil. An extensive survey was conducted in several fields, at different depths, under different farming practices. It was found that disking and plowing improved the uniformity of the nematode populations in the soil, but roto-tilling improved this distribution much more than either disking or plowing.

All three methods were effective only on the upper 6 to 8 inches of soil. Nematode populations decreased below this depth.

Plots were also fumigated and comparisons made between nematode effect and nematode population for 1 and 2 years after fumigation.

Viable nematode populations were substantially reduced and sugar-beet yields were increased by about 50 percent the first season after fumigation. However, by the end of the first season nematode cyst populations had increased to a higher density than non-fumigated plots. Thus, the second sugarbeet crop after fumigation was damaged more severely by nematodes than sugarbeets in plots that had never been fumigated. Uniformity of nematode cysts distribution in the soil was still not satisfactory.

Of all methods tested, rototilling appeared to give a more uniform nematode distribution in the soil.

Additional observation

Nematode infection under certain infection levels causes several observable effects. Wilting under severe infection levels has been consistently reported. Under minimal fertility, nematode infection causes a yellowing similar to nitrogen deficiency. Also, under severe nematode infection just prior to the time that wilting occurs, there is an increased lengthening of the petioles. This increased lengthening is due to an enlargement of the petiole cells. This suggests a nematode induces growth promoting substance. This has been reported in *Phytopathology* 61: 40-41.

Three growth hormones, IAA, 24-D, and gibberellic acid, were sprayed on nematode inoculated sugarbeet plants and the infection rate measured. There was no observed effect of these three hormones on nematode infection by applying them in this manner. However, they did affect plant growth.

Discussion and summary

Within the B. vulgaris species there appears to be no immunity or very little, if any, resistance to sugarbeet nematode infection. In most of the tests conducted for infection rate the variances were all environmental. Therefore, selection for immunity in any of these tests would be of little value. These conclusions were further confirmed by comparing selections obtained from a number of different workers. No difference in infection rate was found between any of the nematode selections nor between the selections and their respective parents.

This, however, does not eliminate the possibility of their being resistant to infection in Beta vulgaris. Even though many sources of genetic material were tested, the entire gene pool within Beta vulgaris was not sampled. In addition, if the environmental error involved in screening for nematode resistance could be reduced substantially, small differences in infection rate could be detected if they exist.

A study of the variances involved is helpful in understanding this problem. The total variance of nematode infected plants can be written as follows:

$$V = V_g + V_{gn} + V_{ne} + V_{ge} + V_e$$

Where V_g = genotypic variance

V_{gn} = genotypic variance of nematode resistance

V_{ne} = The variance of environment times nematode interaction, i.e. the effect of environmental factors on nematode growth, development, infection, etc. Likewise, nematode infection may be affected by a number of factors such as, root-growth, nematode distribution, moisture, temperature, etc.

V_{ge} = The variance of environment times genotype interaction. It is generally assumed that this variance is very small.

V_e = Environmental variance, i.e. all uncontrollable factors affecting the plant.

In all tests the environmental variance (V_e) has been large. In order to detect genetic differences (V_g and V_{gn}), the three environmental variances (V_{ne} , V_{ge} , and V_e) are pooled together and subtracted from the total variance. In all tests, the variance due to nematode times environment interaction (V_{ne}) was significant. Much effort has been expended in order to reduce the nematode environmental interaction (V_{ne}) as well as the environmental variance (V_e). If the genotypic variance (V_g) and the genotype variance for nematode resistance (V_{gn}) are small in relation to either or both of the environmental variances, genetic deviates cannot be detected.

When selecting for infection rate the genotypic variance (V_g) is very small and differences between the total variance and the pooled environmental variances would give estimates of the variance due to nematode resistance (V_{gn}). In all tests designed to measure this variance it was either very small in relation to the environmental variances or it did not exist.

When selecting for yield in the field, the genetic variance (V_g) and the genetic variance for nematode resistance (V_{gn}) could not be separated. Thus, genetically superior selections could be combinations of both of these effects depending upon the relative size of the two variances. Most of the material tested in the field was highly heterozygous. This resulted in a large genetic variance (V_g) and hopefully a large variance for nematode resistance (V_{gn}).

In general terms, the genetic variance (V_g) could be classed as total plant vigor and the variance for nematode resistance (V_{gn}) as tolerance to nematode invasion since no difference in infection rate was detected in this material.

All nematode selections tested thus far, both from this station and several other stations, have shown no reduction in infection rate. However, most have shown significant improvement over their parents in yield trials in nematode infested soils. When grown in non-nematode infected soils, an improvement of the selections over their parents is also observed. This is the general case, but there are some selections that rank high in nematode infested soils, and low in non-nematode infested soils, and some parents that are very poor in nematode soils, but give excellent yields in non-nematode soils. This suggests that most of the improvement in breeding for nematode resistance has been for overall plant vigor, but at the same time there has been a fair amount of improvement for nematode tolerance.

Nematode Trials 1970

D. L. Doney, I. O. Skoyen, and E. D. Whitney

Trial 1 (Salinas, California)

This trial consisted of four lines obtained from H. Rietberg, The Netherlands (RW numbers), five nematode selections made at the Salinas station, and US H9B (table 1).

The testing area was heavily infested with nematodes. The design was a randomized block, replicated 12 times with 20-foot single-row plots. The trial was planted April 20 and harvested October 27. Wilting ratings were taken September 2, September 3, and October 8 after an extended interval between irrigations. At harvest time, data were taken on number of harvested beets, percent sugar, and yield. Poor germination of the five nematode selections resulted in insufficient stands for comparison purposes.

The lines received from H. Rietberg (RW numbers) had been selected for wilting resistance to nematode infection. These lines were not different from each other in wilting resistance, but all showed significantly less wilting than US H9B and the D2 selection. They all outyielded US H9B in this nematode infested soil.

Trial 2 (Salinas, California)

Trial 2 was in the same nematode infested soil and treated the same agronomically as trial 1. This trial consisted of four nematode selections from each of two parents (RW 467 and Acc 107) plus the two parent lines (table 2). US H9B was included as a check variety. The selection entries were the seed generation (produced in 1969) from the original mother beet selections made in the 1968 space-planted trial. The selection criterion was based on the probability of individual roots for yield, percent sugar, and total sugar. The selections in this trial all had high probabilities of being genetically superior to the parent in yield and total sugar. Four were selected for superiority in percent sugar.

No selection was made for wilt resistance, hence, the wilting ratings for the selections were similar to their parents (table 2). There was a significant difference in wilt rating between the parents (table 2). Parent RW 467 was a wilt resistant line obtained from H. Rietberg and showed significantly less wilting than the other varieties.

All selections were greater than their respective parent for yield and gross sugar and all except one were higher in percent sugar. However, most of these differences were not significant. A comparison of selections versus parents gave a significant increase in yield and gross sugar of the selections over the parents.

Trial 3 (Farmington, Utah)

The entries in this trial were selections from two sister lines (590-1 and 590-9) developed by Charles Price, plus the two parents and US H9B as a check variety (table 3). The selections were made for nematode resistance in the same manner as the selections in trial 2. The testing area was relatively free of nematodes. Planting and harvest dates were April 17 and October 13 respectively. Entries were replicated six times in a randomized block with 36-foot single-row plots.

Most selections outyielded their respective parent in root yield and gross sugar but had lower percent sugar than their parent. When all selections were summed over and compared with their respective parents, a significant increase of the selections over their respective parent was obtained for root yield and gross sugar. Several selections outyielded US H9B, but not significantly.

These data indicate that progress in nematode tolerance can be achieved by this method of selection, i.e. selection based on the individual beet probabilities in a space-planted trial.

Table 1. Entry means for wilting ratings, number of roots, percent sugar, yield, and gross sugar for trial 1, 1970. Trial was at Salinas, California, in nematode infected soil.

Entry	Source or parent	\bar{x} wilting rating *	Sept 2	Sept 3	Oct 8	\bar{x} No. of Roots	\bar{x} % Sugar	\bar{x} Yield Tons/acre	\bar{x} Gross sugar lb/acre
RW 268	H. Rietberg	2.25	2.54	2.92	22.4	13.80	20.17	5,544	
RW 368	"	1.96	2.25	2.58	24.2	12.88	21.18	5,477	
RW 468	"	2.21	2.42	2.37	23.8	13.82	23.50	6,483	
RW 567	"	2.42	2.39	2.71	24.8	14.08	20.14	5,684	
US H9B	J. McFarlane	3.33	3.50	3.42	23.3	13.05	17.34	4,514	
D2	Poland	2.96	3.21	3.50	15.4	13.58	13.47	4,100	
1306	D2	-	-	-	7.3	12.65	5.73	-	
8107	"	-	-	-	8.9	12.29	5.45	-	
6808	"	-	-	-	7.5	13.36	5.10	-	
7508	"	-	-	-	9.0	12.2	6.14	-	
\bar{x}		2.52	2.72	2.92	16.7	13.40	13.84	4,751	
LSD .05		.37	.44	.68	2.33	.57	2.63	702	
C.V.		18.2	20.0	27.2	17.1	5.2	23.3	18.0	

* 1 = no wilting, 5 = severely wilted

Table 2. Entry means for wilting ratings, number of roots, percent sugar, yield, and gross sugar for trial 2, 1970. Trial was at Salinas, California, in nematode infected soil.

Entry	Source or parent	\bar{x} wilting rating*			\bar{x}	No. of Roots	\bar{x}	% Sugar	\bar{x}	Yield Tons/acre	\bar{x}	Gross sugar lb/acre
		Sept 2	Sept 3	Oct 8								
0104	RW 467	1.75	2.33	2.58		22.0		15.20		18.94		5,789
5801	"	1.83	2.33	2.58		19.8		15.60		17.81		5,574
1503	"	1.67	2.08	2.58		20.8		15.45		18.20		5,621
3809	"	2.00	2.25	2.25		19.2		15.42		17.61		5,434
RW 467	H. Rietberg	1.42	2.25	2.33		22.0		15.18		16.01		4,872
4502	Acc 107	2.33	2.92	2.33		21.8		14.95		15.74		4,751
5409	"	2.33	2.75	2.58		23.7		13.30		15.12		4,236
5806	"	1.25	1.75	1.67		22.5		14.17		17.46		4,938
3810	"	2.58	3.25	2.83		22.8		14.90		14.85		4,423
AC 107	G. J. Curtis	2.17	2.67	2.42		17.5		14.13		14.22		4,059
US H9B	J. McFarlane	3.50	3.33	2.67		22.2		13.32		17.69		4,676
LSD .05		0.75	0.69	0.87		3.0		0.85		3.09		973
C.V.		31.5	23.6	30.9		-		5.0		16.0		-
\bar{x} of RW 467 Selections		1.81	2.25	2.50		20.5		15.42		18.14		5,602
\bar{x} of ACC 107 Selections		2.12	2.67	2.35		22.7		14.33		15.79		4,592

* 1 = no wilting, 5 = severely wilted

Table 3. Entry means for number of roots, percent sugar, yield, and gross sugar for trial 3. Trial was at Farmington, Utah in nematode-free soil.

		\bar{x}	\bar{x}	\bar{x}	\bar{x}
	Source or parent	No. of Roots	% Sugar	Yield Tons/acre	Gross sugar lbs/acre
6805	590-1	42.0	16.38	31.24	10,230
0109	"	39.5	15.53	29.12	9,042
2006	"	38.0	15.13	33.51	10,144
590-1	C. Price	36.0	15.20	29.08	8,826
7701	590-9	34.2	15.27	31.40	9,781
3804	"	38.8	14.90	35.56	10,603
5407	"	41.7	15.23	37.16	11,302
4809	"	40.5	15.23	36.18	11,018
590-9	C. Price	32.4	16.07	28.93	9,289
US H9B	J. McFarlane	41.2	15.87	34.94	11,066
LSD .05		4.7	.62	4.82	1,496
C.V.		13.2	3.4	15.9	15.8
\bar{x} of 590-1 Selections		39.8	15.68	31.29	9,805
\bar{x} of 590-9 Selections		38.8	15.16	35.07	10,676

NEMATODOLOGY INVESTIGATIONS - 1970

Arnold E. Steele

Influence of inoculum level on development of Heterodera schachtii on sugarbeet (Beta vulgaris L.).

The objectives of this test were to (1) develop a method of determining the relative success of males and females in developing on host plants and (2) to apply this method to determine whether or not the sex ratio of the sugarbeet nematode may be influenced by infection density.

Mature fresh nematode cysts were inoculated on Beta vulgaris L. Cultivar U.S. 75 at the time seedlings were transplanted from sand to sterilized soil. Cysts were inoculated at the rates of 5, 10, 20 or 40 cysts per plant. Each treatment was replicated five times and each replication contained 2 plants. The plants were allowed to grow in a greenhouse 21 days after which 20 plants were washed and placed in screens within individual funnels, where they were kept an additional 30 days. Sufficient water was added from time to time to keep the roots just covered with water. Approximately 10 ml of water was drained from each funnel daily and examined for adult males of the sugarbeet nematode.

Thirty-one days after inoculation another 20 plants were washed, weighed and the roots and soil examined for mature females and cysts. Data recorded in table 1 were analysed for statistical significance by the analysis of variance method.

Males did not begin to emerge until the 22nd day after inoculation (Fig. 1). The rate of emergence increased to about the 30th day after inoculation and then decreased at about the same rate. The number of males emerging from the 26th day to the 37th day amounted to 78% of the total number emerged from the 22nd to the 43rd day. When the plants were discarded 51 days after inoculation a total of 5,671 males had emerged; 21 males emerged on the 51st day.

Significantly fewer males emerged from plants inoculated with 5 or 10 cysts per plant than from plants inoculated with 40 cysts. The data were not sufficient to indicate whether males increase uniformly with increasing inoculum or if the development of males was inhibited at low inoculum levels.

Increasing the level of inoculum from 5 to 10, 20, or 40 cysts per plant did not significantly increase the number of females per plant. Similar numbers of females were recovered from plants inoculated with 5, 10, or 20 cysts per plants. However the lowest inoculation rate gave the highest number of females recovered per cyst inoculated.

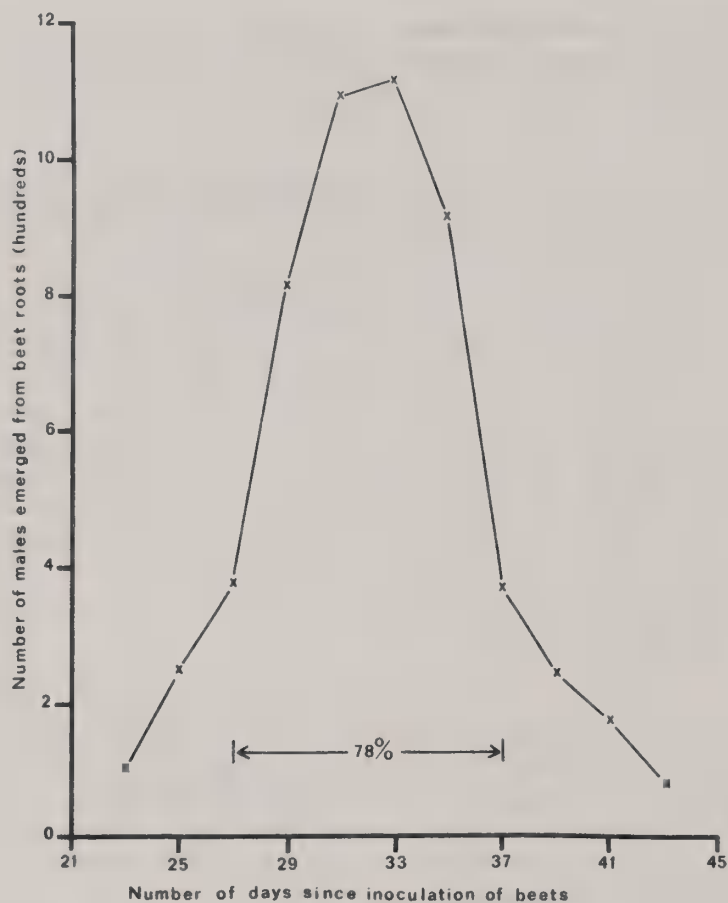


Figure 1. Emergence of adult male *H. schachtii* from roots of sugarbeet harvested 21 days after inoculation.

Table 1. The influence of inoculum level on plant weights and nematode development on sugarbeet^{1/}

No. of cysts inoculated	Top Weight	Root Weight	Total Weight	Ratio top/root	No. Males	No. Females	Ratio males/females	Total nematodes
5	127.2	108.2	235.4	1.18	228	385	0.59	613
10	109.0	81.1	190.1	1.34	1060	312	3.40	1372
20	93.3	70.6	163.9	1.32	1246	256	4.87	1502
40	94.8	81.3	176.1	1.17	3137	1518	2.07	4655
Significance	N.S.	N.S.	N.S.			N.S.		
LSD .05	-	-	-		1336	-		

^{1/} Each figure given is the total data obtained from 5 plants. Counts of males and females taken from separate plants. Counts of females and plant weights taken from the same plants.

Influence of inoculum level of Heterodera schachtii and environment on cyst production and growth of sugarbeet.

A test was undertaken to determine if cyst production increases in proportion to increasing nematode inoculum, the effects of increasing inoculum on growth of sugarbeet, and the effects of environment on population increase and growth of sugarbeet.

Sugarbeets were grown 90 - 120 days in soil infested with the sugarbeet nematode Heterodera schachtii. The soil in the root zone of infested plants was washed and screened and newly formed cysts were removed from the soil debris and stored 10 days at 5° C. Sugarbeets were germinated in steam sterilized sand and transplanted in the cotyledon stage to individual six-inch clay pots containing sterilized soil. Cysts were added to the pots at the time of transplanting. The levels of nematode inoculum were 0, 20, or 60 cysts per plants. Half of the plants were maintained in the greenhouse and half were kept in a growth chamber. Treatments were replicated 5 times and arranged in a completely random design in each environment.

Temperature data of the environments were as follows: Greenhouse - 145 hours above 85° F, 179 hours below 70° F, 95° F maximum, 64° F minimum temperature. Degree hours amounted to 48,451 with an average temperature of 76.1° F. Constant soil temperature in a growth chamber was 75.2° F. Plants were exposed to incandescent and high intensity fluorescent illumination for 16 hours and darkness for 8 hours per day.

Thirty days after transplanting, the plants were removed from soil, washed, weighed, and the roots and soil examined for adult females and cysts. Data listed in tables 2, 3, and 4 were examined for statistical significance.

Results show that a constant temperature environment of 75.2° F resulted in significantly higher populations of sugarbeet nematode and greater yields of tops and roots of sugarbeet than a fluctuating environment in which the average temperature was 76.1° F. Increase of cysts on sugarbeets was not proportionate to increasing inoculum, suggesting that unknown factors effected a decrease in the rate of penetration and development at the higher inoculum level. While plants inoculated with 60 cysts per plant showed a slight decrease in mean root weight, the top weights were significantly greater in plants receiving 20 cysts. Moreover, top weights of sugarbeet were significantly influenced by the interaction of inoculum level and environment. Reports in literature indicate that the sex ratio of the sugarbeet nematode may be influenced by environmental factors and the initial density of the nematode population.

Table 2. Influence of nematode inoculum level and environment on development of Heterodera schachtii and Beta vulgaris L.

Environment	Number of cysts inoculated	Top Weight	Root Weight	Total Weight	Ratio Top/root	White females	New brown cysts	Total Nematodes	Nematodes per gm root
Greenhouse	0	137.5 ^{1/}	59.9	197.4	2.30	0	0	0	0
"	20	146.2	62.2	208.4	2.35	104	0	104	1.8
"	60	117.2	50.2	167.4	2.33	58	0	58	1.2
Total		400.9	172.3	573.2	2.33	162	0	162	1.1
Growth Chamber	0	223.8	154.2	378.0	1.45	0	0	0	0
"	20	262.8	152.8	415.6	1.72	3682	43	3725	24.4
"	60	250.3	146.7	397.0	1.71	3971	243	4214	28.7
Total		736.9	453.7	1190.6	1.62	7653	286	7939	53.1
Significance		**	**	**				**	
LSD .05			52	93				1785	

^{1/} Each figure represents 5 plants harvested 30 days after inoculation.

Table 3. Influence of cyst inoculum and environment on top weights of sugarbeet.

Cyst inoculum level	Environment		Total	Average
	Greenhouse	Growth Chamber		
0	137.5	223.8	361.3	180.7
20	146.2	262.8	409.0	204.5
60	<u>117.2</u>	<u>250.3</u>	<u>367.5</u>	183.8
Total	400.9	736.9	1137.8	
Average	133.6	249.0		

Table 4. Analysis of Variance

Source	Degrees of Freedom	Sums of Square	Mean Square	F.
Total	29	4682.58		
Population (P)	2	3763.20	1881.60	164.2**
Environment (E)	1	134.50	134.50	11.7**
Interaction (PXE)	<u>2</u>	<u>112.72</u>	<u>56.36</u>	49 *
Error	24	675.16	11.46	

Influence of root size on development of H. schachtii on sugarbeet.

Two hybrid varieties of sugarbeet^{1/} were tested to determine the effects of root size on development of female sugarbeet nematode. Seed of each variety were germinated and grown in individual 8 inch clay pots containing sterilized soil. Fifty sugarbeet nematode cysts filled with eggs and larvae were added to each pot either at time of seeding or 30 days after seeding. The 24 pots containing sugarbeets grown in infested soil (6 replications of 2 varieties of 2 ages) were arranged in a completely randomized design and grown 30 days in a greenhouse. The plants were washed, weighed, and the roots and soil debris examined for adult sugarbeet females and cysts.

As shown by table 5 there were significant differences between varieties and between plants inoculated at different ages in the number of females and cysts developing on sugarbeet roots. In addition, there was an interaction between varieties and age which affected development of nematodes.

The data suggest that the susceptibility to nematode development for the two varieties may differ. The data also suggest that the practice of planting sugarbeets early when soil temperatures are low to 'get the plant off to a good start' may result in exceptionally high nematode populations later in the season by providing increased root growth.

The varieties will be retested to ascertain whether or not differences in nematode populations occur.

Table 5. Weights of 2 varieties of sugarbeet harvested 30 and 60 days after inoculation with H. schachtii.

Variety	Age	Top Weight	Root Weight	Total Weight
1	30	2.4 ^{2/}	0.2	2.6
2	30	2.2	0.2	2.4
1	60	73.3	27.2	100.5
2	60	96.2	31.8	128.0

^{1/}Seed obtained from Irvin O. Skoyen, Sugarbeet Investigations.

^{2/}Average weights (gms) of 6 plants.

Table 6. Influence of plant age and selection on production of H. schachtii females

Age ^{1/}	Variety		Total	Average
	1	2		
30	568	197	765	383
60	<u>5681</u>	<u>2269</u>	<u>7950</u>	3975
Total	6249	2466	8715	
Average	3125	1233		

Table 7. Analysis of Variance

Source	Degrees of Freedom	Sums of Squares	Mean square	F
Total	23	3,548,961		
Age A	1	2,051,010	2,051,010	98.76 **
Variety (V)	1	596,296	596,296	28.71 **
Interaction (AXS)	1	486,319	486,319	23.42 **
Error	20	415,336	20,767	

^{1/} Age of plants at harvest 30 days after inoculation with 50 cysts per plant.

Penetration and development of the sugarbeet nematode on
defoliated sugarbeets and on root debris.

A test was undertaken to determine whether or not the sugarbeet nematode can develop on fresh or dried sugarbeet roots from which tops have been removed. Sixty-eight plants grown 14 days and 14 plants grown 67 days in sterilized soil were washed and the tops removed. The average weight of roots of the 14 day old plants was 29.4 mg whereas the 67 day old plants averaged 7.3 grams per root. Half of the roots of each plant group were dried at 50° C for 48 hours. Tops and lateral roots were removed from several plants grown 67 days in sterilized soil. The remaining tap roots were sliced across the root axis to form discs approximately 1 cm in diameter and 0.5 cm thick.

The variously treated roots were buried to a depth of 1 inch in clay pots containing sterilized soil and the contents of 50 broken cysts were added to each pot. The pots were incubated at 24° C for 17 and 30 days during which time the soil surface in the pots were kept moist. The roots and soil debris were washed and examined for sugarbeet nematode.

Both male and female H. schachtii penetrated and developed to maturity on 6 out of 20 slices of tap root. Females contained eggs with moving, developing embryos. Females developed on both cut surfaces and root surfaces of sugarbeet. Females which developed on cut surfaces did so near the periphery of the discs close to the root surface; none developed near the center of the discs. Many females developed on lateral roots which were attached to large tap roots of plants from which leaves were removed. Neither males nor females developed on dried roots regardless of size or on fresh roots of small defoliated plants which did not have large well developed tap root. This indicated that the sugarbeet nematode can only feed and develop on living plant material. However, these results suggest that the sugarbeet nematode can penetrate and develop to maturity on defoliated beets or on even small pieces of living root debris which are invariably present after harvest of sugarbeets.

• * •

Gross morphological changes in roots of young sugarbeet infected or
not infected with the sugarbeet nematode.

In the course of examining roots of young sugarbeet plants for nematodes it was observed that the roots frequently contained breaks in the cortical tissues. These breaks varied from fine fissures to deep cracks. Close examination of roots of sugarbeet and swiss chard grown in sterilized or nematode infested soil also showed extensive sloughing of the epidermis and cortical parenchyma. Both infected and non-infected roots exhibited some rifts but infected roots often contained cracks which extended through the cortex to the central cylinder. Roots of young, 20 day old plants usually rifts but infected roots often contained cracks which extended through the cortex to the central cylinder. Roots of young, 20 day old plants usually



Figures 2-4. Roots of young sugarbeet with sloughing of epidermis.
Figures 5-7. Roots of sugarbeet infected with H. schachtii fissures,
rifts, and cracks in the cortical tissues of the roots.

contained fine fissures while roots of older plants invariably contained rifts at junctures of roots and hypocotyls. Deep cracking frequently occurred in areas where roots were bent or twisted out of line with the root axis. In many instances, swollen female sugarbeet nematodes were found deep within cracks and within the shallow rifts where lateral roots emerged from tap roots. A total of 12 maturing juvenile males and females were found within a single elongated rift in the hypocotyl of a sugarbeet 17 days after transplanting to soil infested with 50 cysts. The plant was extremely stunted and the roots were heavily parasitized by larvae. In localized areas of the roots, there were often rosettes of proliferated lateral roots; invariably several female nematodes were found near the junctures of lateral and tap roots. Roots of resistant B. patellaris and immune B. webbiana grown in infested or sterilized soil for 20 to 40 days showed extensive sloughing of epidermis without sloughing of cortical parenchyma or formation of rifts.

Artschwager reported that in the normal course of sugarbeet root development, the central cylinder increases in size but little growth occurs in the cortex which is at first stretched but later ruptures and collapses, producing fine fissures which gradually widen. Finally the cortex is sloughed off.

While small fissures and sloughing of epidermal and cortical tissues were evident even in roots of healthy plants, deep rifts and cracks also were found in roots of infested plants.

According to information contained in the literature, cracking in sweet potato is a rupture of the inactive outer tissues due to internal pressure from the expanding vascular cylinder, possibly initiated by rapid influx of moisture following a prolonged drought. However, other workers obtained a significant correlation between root knot index and the number of cracks and cracked roots per root system. They postulated that nematodes may inhibit localized cell division in actively growing roots. Continued centripetal cell division and growth of underlying tissues subsequently cause a rupture through the less active infected cortical cells. It is well known that nematodes stimulate the proliferation of lateral roots which originate in the pericycle region. The initial cells of the syncytial complex are also formed in this region. Consequently, rift formation in young sugarbeet may also result from stresses set up in the cortex by growth and reorganization of stelar tissues.

* * *

Emergence of adult male Heterodera schachtii from sugarbeet maintained in liquid nutrient solution.

Two tests were undertaken to determine the effects of growing sugarbeet in nutrient solutions with and without high intensity illumination on emergence of male sugarbeet nematodes.

In one test 30 seedlings were transplanted to sterilized soil. Each seedling was inoculated with 40 full cysts and kept in a growth chamber with high intensity illumination. Air temperature of the chamber was maintained at 24° C. Seventeen days after inoculation the plants were removed and the roots carefully washed and placed in aerated Hoagland's solution within funnels as illustrated in figure 8. Half of the plants received high intensity illumination 16 hours per day; the other half were kept in incubators without light. About 10 ml of solution was drained from each funnel daily for 17 days and the solution examined for adult males of H. schachtii.

The methods used in a second test were essentially those described except that 16 plants were used. Eight plants kept in aerated nutrient solution received high intensity illuminations while another eight plants were maintained in aerated nutrient solution on a bench in the laboratory.

Greater numbers of males emerged from roots of plants excluded from light in incubators or kept in the laboratory than emerged from plants exposed to high intensity illumination. Emergence of males in the first test were: Incubator - 1,887, Growth chamber - 637. Emergence in the second test was: Laboratory - 1,864, Growth chamber - 390, LSD .05 - 136. Several factors may account for the differences in emergence of males. Higher temperatures within funnels kept in the growth chamber may inhibit emergence, adverse factors within plants excluded from light may induce males to leave the root, or the host root tissues may be altered so that they provide less of a barrier to emerging males.

* * *

Attempts to extract hatch factor from sugarbeet root diffusate with alcohol and ether.

A test was undertaken to extract hatch factor with absolute ethyl alcohol (ETOH), 95% ethyl alcohol and absolute ether.

Two sample of 2.25 grams of dried residue were obtained by vacuum distillation of sugarbeet root diffusate. The dried residue of sample number 1 was a light cream color and was easily pulverized with a mortar and pestle. The residue of sample number 2 was light chocolate color, was very hygroscopic, and became gummy when ground with a mortar and pestle. Hatching tests with water solutions of the two samples revealed that hatches in sample number 1 amounted to about 72% of that in sample number 2. The samples were added to 22.5 ml of absolute ETOH, or absolute ether. The solid residue after extraction with absolute ETOH was added to 22.5 ml of 95% ETOH. All solutions were filtered and dried and the residue added to sufficient amounts of distilled water to obtain concentrations equivalent to 20 and 100% of the untreated sugarbeet root diffusate. Each of the solutions were tested for their effects on hatching and emergence of larvae from 5 replications, each of 40 cysts, for a period of 6 weeks. Data are listed in table 8.

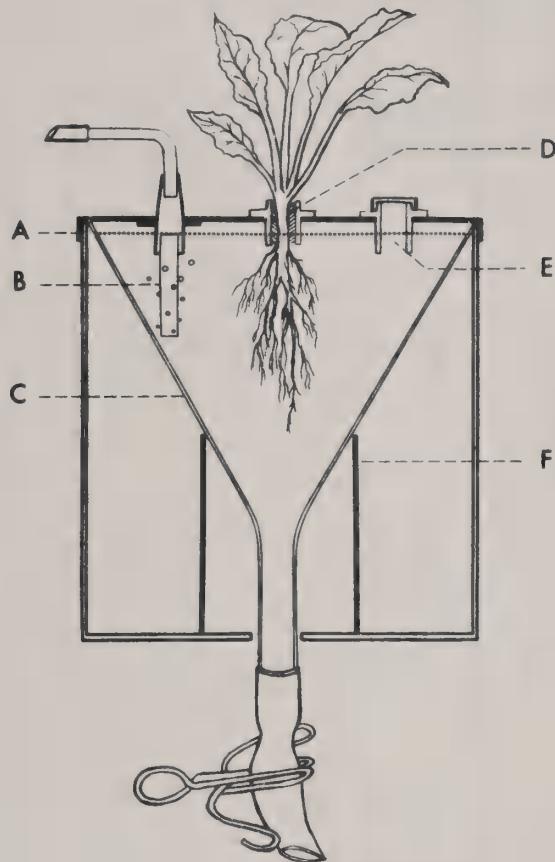


Figure 8. Apparatus for growing young sugarbeet plants to facilitate collection of adult males. A. Plastic cover. B. Aerator. C. Funnel. D. Loose latex foam rubber or cotton packing. E. Service part. F. Spacer.

Table 8. Influence of fractions of sugarbeet root diffusate on emergence of larvae from cysts of Heterodera schachtii.

Fraction	Solvent	Sample 1		Sample 2	
		% Concentration		% Concentration	
		20	100	20	100
Extract	95% ETOH	4,279 ^{2/}	19,898	5,232	7,569
"	Abs. ETOH	10,242	34,851	4,466	23,042
"	Abs. Ether	-	-	-	2,288
Residue after extraction ^{1/}		16,355	37,334	21,721	45,846
Concentrate before extraction		23,318	29,809	28,399	30,580
Tap Water		-	-	-	2,656

^{1/} Residue after extraction with absolute ETOH followed by extraction with 95% ETOH. Sample No. 2 residue was also eluted with absolute ether after treatment with ETOH.

^{2/} Each figure is a total hatch from 5 replications of 40 cysts during a period of 6 weeks.

Results indicated that hatch factor ~~was~~ not soluable in absolute ether.

Hatch factor ~~was~~ more soluable in absolute ETOH than 95% ETOH although it appeared that 10 ml ETOH per gram of dried residue ~~was~~ not sufficient alcohol to extract the total amount of hatch factor present in the residue; perhaps 20-30 ml ETOH per gram of residue would be sufficient to extract all of the hatch factor.

Cooperator: J. M. Fife, Sugarbeet Investigations.

INTERSPECIFIC HYBRIDIZATION

VULGARIS-PROCUMBENS HYBRIDS

Helen Savitsky

Obtaining nematode resistant hybrids: Four nematode resistant trisomics (19 chromosomes) were selected from 6,750 B₁ hybrids, as was discussed in the 1969 report. The B₁ trisomics were pollinated by nematode susceptible diploid beets. Nematode resistant plants were selected from the progenies of trisomic hybrids. The resistant plants were pollinated in groups interse, but some diploid nematode susceptible pollinators were added to provide sufficient viable pollen.

To test the hybrids for nematode resistance, seedlings were planted in nematode infested soil and the resistant plants were selected in two groups. The first group included plants with 0-5 cysts and the second group included plants with 6-10 cysts. The plants with larger numbers of cysts were discarded. All selected plants were tested three times. In the second and in the third tests 15 additional viable cysts were added to the infested soil which was placed around each plant. The final selection was made after the completion of the three tests. The chromosome number was determined in each of the selected plants.

Results: In the B₂ progenies of trisomic hybrids many plants were nematode susceptible, but highly resistant plants were found in all progenies. In three tests, some resistant plants had no cysts on the roots, others had 1 to 4 cysts, and in a few plants 7 or 8 cysts were observed on the roots in one of the three tests. Almost all hybrids selected belonged to the first group. All resistant plants had fleshy roots and resembled sugarbeet. Cytological analysis revealed that some of the B₂ resistant hybrids were trisomics with 19 chromosomes, and some were diploids with 18 chromosomes.

Seed was harvested from some resistant trisomics which flowered earlier and the B₃ hybrids were tested for resistance this year. Again, the resistant trisomics and some resistant diploid plants were selected. In this way, Beta procumbens chromosomes responsible for resistance were transferred to the following B₃ generation. These trisomics provide a source from which new resistant trisomics and resistant diploid hybrids may be obtained. These results are very important and demonstrate a method for the development of nematode resistant lines.

During 1969 and 1970, B₂ and B₃ nematode resistant populations were obtained which consisted of 92 trisomics and 75 diploid plants. In addition to nematode resistance, the trisomics and the resistant diploid plants inherited from the wild species an easy bolting tendency, a long period of flowering, and the ability to produce tumors (result of coexistence of B. vulgaris and B. procumbens chromosomes). In some plants, seed shattered easily, like in B. procumbens. The grade of fertility varied in different plants, but in general fertility was not high.

The diploid resistant hybrids resulted obviously from crossing over or translocation between B. procumbens and B. vulgaris chromosomes. The segment of the B. procumbens chromosome which is responsible for resistance was incorporated into a B. vulgaris chromosome. The length of the B. procumbens segment transmitted will be different in the individual plants. The length of segments may affect the regularity of meiosis and the transmission of the segment to the following generations. If translocation took place, the B. procumbens segments may be attached to different chromosomes (to different linkage groups). It must be expected that resistance will not be transferred from all diploid hybrids. When transferred, the level of resistance will vary from plant to plant.

Seeds harvested from diploid B₂ nematode resistant hybrids were planted and the progenies are now being tested for resistance. After the first check, the resistant B₃ hybrids were selected in these progenies, although the number of resistant plants was not large. The plants selected will be exposed to the second and third tests. These first data showed that resistance could be definitely transmitted from diploid hybrids, but the frequency of transmission in the individual progenies is not known at the present time.

The observation of comparatively large quantities of diploid resistant hybrids indicates that they occur regularly in the progenies of trisomics. They are basic material from which highly nematode resistant lines should be developed. The last step in resistance transmission will be the development of highly resistant diploid lines with regular meiosis and a high frequency of resistance transmission. Such lines may be used to incorporate resistance into commercial varieties. Different methods including hybridization, probably X-ray irradiation, and selection for resistance accompanied by cytological studies will be used to achieve this goal.

Meiosis in nematode resistant trisomics: Behavior of B. procumbens chromosome during meiosis in B. vulgaris-B. procumbens trisomics is of great importance. Three possibilities may be expected: 1/ the B. procumbens chromosome may be thrown out into the cytoplasm and lost, 2/ it may reach the poles and be included in the gametes, or 3/ it may associate to some extent with a B. vulgaris chromosome.

Cytological study showed that the outline of meiosis in trisomics was very regular, because of the regular division of 9 B. vulgaris bivalents. However, in some PMCs (pollen mother cells) the B. procumbens chromosome lacking a partner for association was thrown into the cytoplasm at the 1st metaphase. Micronuclei were rarely formed and the B. procumbens chromosome obviously disintegrated into the cytoplasm. In the other PMCs, the chromosome of B. procumbens was oriented at the equatorial plate, transferred as a univalent to the poles, and included in the gametes. Such gametes produced new resistant trisomics in the progeny of parental trisomics. In some PMCs the trivalent associations

consisting of two B. vulgaris and one B. procumbens chromosome were observed at diakinesis. Due to crossing over, the exchange of segments occurred between the chromosomes of different species. Exchange of segments was for the most part terminal. Closed rings of three, which indicate the occurrence of translocations, could rarely be observed. Cytological data confirmed that the appearance of diploid resistant hybrids in the progenies of trisomics was due to the crossover gametes possessing segments of a B. procumbens chromosome.

The majority of the plants in the progenies of trisomics were nematode susceptible. If B. procumbens chromosomes are not thrown out, but are always included in the gametes, only 50% of gametes would contain this chromosome and transfer the resistance. The other 50% of gametes would transfer nematode susceptibility. The elimination of B. procumbens chromosome in the cytoplasm reduces considerably the chances of transmission of resistance.

Chromosome association in B. vulgaris-B. procumbens trisomics leads to the conclusion: 1/ a complete B. procumbens chromosome or the segments of this chromosome are included in some gametes of B. vulgaris-B. procumbens trisomics; 2/ in the progenies of trisomics some susceptible plants will have 19 chromosomes. Such plants are derived from crossover gametes which lost the segment of the B. procumbens chromosome responsible for resistance; 3/ the gene for nematode resistance apparently is not located close to the centromere, which facilitates its transmission by terminal exchanges.

VULGARIS-COROLLIFLORA HYBRIDS

Helen Savitsky and J. S. McFarlane

In the B₃ population of vulgaris-corolliflora hybrids, 36 curly top resistant plants were selected by Dr. Bennett after two inoculations with curly top virus, strain 11. These plants were grown for seed production. The general fertility was better in these B₃ plants than in the preceding B₂ generation. However, the degree of fertility varied considerably among different plants. The number of chromosomes in these curly top resistant backcross plants varied from 18 to 27, but the majority of the plants had 19 and 20 chromosomes. Some resistant plants had 18 chromosomes. Apparently these plants had a segment of B. corolliflora chromosome which had been incorporated into a B. vulgaris chromosome by crossing over or translocation.

All the selected plants developed large fleshy roots. The plants belonged to different morphological types which were determined by the chromosomes acquired from the wild species. The plants with 18 and 19 chromosomes resembled sugarbeet, whereas the plants with larger number of chromosomes tended to resemble the wild species.

Seed from individual plants was planted and 576 B₄ seedlings were tested for curly top resistance. Plants of each progeny were divided into two groups. One group was inoculated with the Los Banos strain of curly top virus and another group with the highly virulent Logan strain. Inoculation of plants, classification for damage, and selection for resistance was done by Dr. McFarlane. In both groups 377 (65.45%) plants were highly susceptible, 175 (30.38%) plants showed only mild symptoms, and 24 (4.17%) plants showed no symptoms and were apparently immune or highly resistant. This last group of plants was reinoculated with the Logan strain to make sure they had not escaped infection. They remained highly resistant after reinoculation.

The B₄ population of the vulgaris-corolliflora hybrids showed a high level of resistance to the most virulent curly top strains. Even after inoculation with the Logan strain, 30 percent of the plants showed only very mild curly top symptoms.

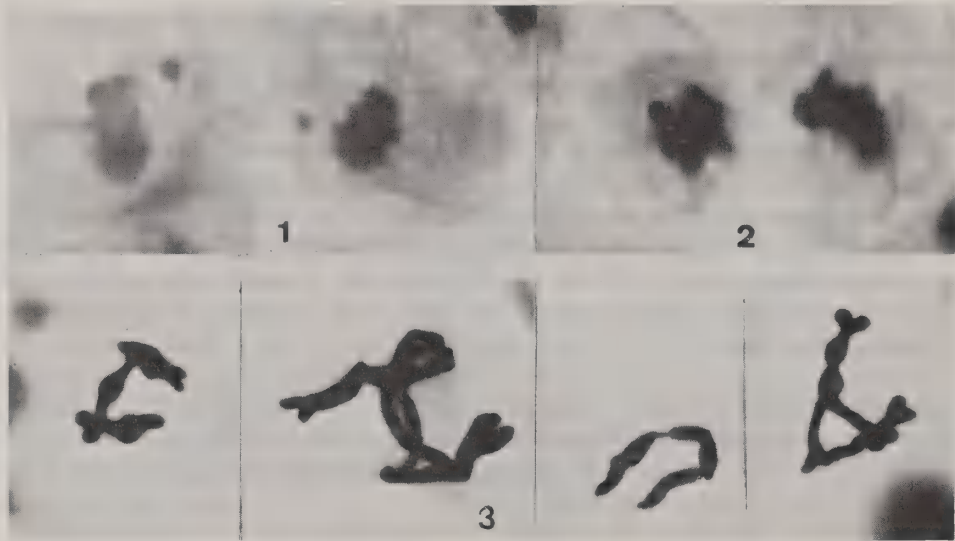


Fig. 1-3 Meiosis in nematode resistant vulgaris-procumbens trisomics (19 chromosomes)

Fig. 1 I metaphase - B. procumbens chromosome thrown into cytoplasm

Fig. 2 I metaphase - B. procumbens chromosome included in equatorial plate

Fig. 3 Association between B. vulgaris and B. procumbens chromosomes: trivalents formed at diakinesis



Fig. 4 Morphological types of curly top resistant vulgaris-corolliflora hybrids: left plant has 19 chromosomes and resembles sugarbeet, right plant has 25 chromosomes and resembles B. corolliflora.

VIRUS INVESTIGATIONS

J. E. Duffus

There are many similarities between beet western yellows virus (BWYV), the most common yellowing virus of sugarbeet in the United States (Duffus, 1960), and beet mild yellowing virus (BMV) which is the most prevalent virus of beet in Europe. The viruses are transmitted in essentially the same manner by the green peach aphid, Myzus persicae (Sulzer); and they induce similar or identical symptoms in a number of host species including Capsella bursa-pastoris (L.) Medic. (Shepherd's purse), Senecio vulgaris L. (groundsel) and Claytonia perfoliata Donn. Some isolates of BWYV, however, do not infect sugarbeet; and there is some evidence that the yellowing symptoms of BMV on sugarbeet in Europe differ from those caused by beet-infecting strains of BWYV in the U.S.A. For example, in Europe the older leaves of BMV-infected beet in the field usually become orange-colored, unlike those infected with the beet yellows virus (BYV), whereas the symptoms of BWYV and BYV in the United States are usually difficult to distinguish on grounds of color alone. In addition, BMV has a very restricted host range (23 species in 8 families) compared with the very wide host range of BWYV (96 species in 21 families).

Field observations in many areas of England and Scotland, including Cambridgeshire, Bedfordshire and Perthshire, suggested the presence of a virus resembling BWYV in weeds and crop plants some of which are hosts of BWYV but not of BMV (Russell & Duffus, 1970). Yellowing symptoms were observed on Malva sylvestris L., Brassica spp., Sisymbrium officinale (L.) Scop., Papaver rhoeas L., Geranium dissectum L., Echium vulgare L., and Lactuca sativa L., which are not hosts of BMV, and on C. bursa-pastoris and Senecio vulgaris which are hosts of both BMV and BWYV.

The results of several experiments establish a serological relationship between BWYV and yellowing virus isolates from weeds and lettuce in England (See Abstract Duffus & Russell, 1970). They show for the first time that BWYV occurs outside the United States of America. In the United States, strains of BWYV can induce serious diseases of sugarbeet, lettuce, radish, turnip, broccoli, cauliflower, and flax and many strains have a very wide range of weed hosts which can significantly affect the epidemiology of the diseases.

It is interesting that the English isolates, studied thus far have ■ somewhat restricted host range and that none has infected sugarbeet or radish. Also, all isolates of BMV collected from sugarbeet fields in eastern England have failed to infect lettuce, radish or chinese cabbage. According to the available evidence, therefore, BWYV isolates from lettuce do not constitute ■ threat to the sugarbeet crop in England.

The severe chlorosis and stunting of infected lettuce plants in Bedfordshire in 1968 and 1969 (Russell & Duffus, 1970), suggests that BWYV may be of considerable economic importance in lettuce crops in Britain. Lettuce cultivars of the Butterhead type are more susceptible to damage by isolates of BWYV than are cultivars of the Crisphead type. The chief symptoms, interveinal yellowing and stunting are especially important on cultivars of the Butterhead type which tend to have loose heads and a more open appearance. Even late symptoms give the plant an unsightly appearance and reduce its market value.

The greater tolerance to symptoms exhibited by lettuce cultivars of the Great Lakes type to BWYV may be partially responsible for shifts from the Butterhead types to Crisphead types in the Salinas Valley of California.

The present investigations have not helped to clarify the inter-relationships of BMYV and BWYV, but further serological and host-range studies of several isolates of the two viruses are planned, to provide more information on this subject. Such information could be very important in programs of breeding for resistance to virus yellows of sugarbeet. For example, if beet western yellows virus (BWYV) and one or more of the other viruses such as beet mild yellowing virus (BMYV) are shown to be unrelated or only distantly related to each other, it is unlikely that plants which are resistant to one virus will necessarily be resistant to the other. Under these circumstances both BMYV and BWYV would be a threat to sugarbeet in America and Europe and it would be necessary to test simultaneously for resistance to BWYV, BMYV and BYV in both continents. If, on the other hand, BWYV and BMYV are closely related, resistance to one virus would probably be associated with resistance to the other and the present programs of breeding for resistance to virus yellows in Europe and America are probably adequate.

Evaluation of Curly Top Virus Field Inoculations on Sugarbeet

I. O. Skoyen and J. E. Duffus

The resistance of sugarbeets to infection and resistance to injury from curly top virus at later stages of plant development has been well demonstrated. However, actual damage and yield losses due to late infection and the effects of different levels of curly top infection on susceptible and resistant varieties is not known. This could be established by controlled field tests with known curly top isolates with varieties of known resistance and in areas where uninoculated plants could be kept free of curly top viruses. This led to a preliminary experiment in 1970 which had as objectives, (1) to develop a method to insure a high percentage of infected plants with individual field plant inoculations, (2) to determine the plant age where inoculation would produce the highest infection and cause damage but not kill the plants, and (3) to determine the relationship of strain virulence to detectable symptoms in the field.

The monogerm hybrid varieties, 868H4 and US H9A, were planted in a factorial experiment in a randomized complete block design on May 13, 1970, at the U.S. Research Station, Salinas, California. The four blocks were considered the replications. Plots were 27 feet long with plants spaced approximately 12 inches apart. The treatments were varieties at two levels, curly top at three levels and plant age at the time of inoculation, two levels. The varieties used have the same F₁ hybrid female parent, 569H3. The pollinator for 868H4 is US 75, the original source of the yellows resistant line C413, which is the US H9A pollinator. The open pollinated line C413 is the result of five successive selections for virus yellows resistance originating from US 75. Since US 75 has good resistance to prevalent strains of curly top virus, it was of interest to compare its resistance with that of the C413 selection. Curly top treatment levels were none, a moderately severe isolate (MSI) and a severe isolate (SI). The plant ages at time of inoculation were 4 weeks (4-6 leaf stage) and 9 weeks (25-30 leaf stage).

The first inoculation was made by placing two or three viruliferous leafhoppers in a small cage, made from 25-mm diam acrylic tubing covered at each end by nylon stocking material, and attaching a cage to a leaf of each test plant. Two or three days later the cages were checked for leafhopper survival and also each cage was shifted to a different plant. Cages with dead leafhoppers were replaced with cages containing living insects. This procedure was repeated for the second date of inoculation except that two cages were used per plant. Uninoculated check plots showed no curly top infection throughout the season.

Plot fertilization and irrigation practices were adequate for good growth. The test was harvested October 27, 1970.

Results and Discussion

Test results and analysis of variance mean squares are shown in Table 1. Highly significant differences are indicated for curly top isolates, plant age at the time of inoculation, and percent infection at different ages. Also, differences in percent infection between isolates were significant (.05). An interaction was shown between curly top isolates and plant age at inoculation which indicates that the most damage occurred in the youngest plants inoculated with the more virulent isolate of curly top virus.

The percent curly top infection that could be obtained in field inoculated plants was of primary interest in the experiment. If high percentages of infection could be induced then it should be possible to compare the damage caused by combinations of viruses, such as curly top and virus yellows, with that of the viruses singly and with healthy plants. Curly top infection levels ranged from 82 - 91 percent in the early inoculations. These were significantly higher than the infection levels observed in plants inoculated at 9 weeks of age. This was a demonstration of increasing resistance to infection as plants increase in size and/or age. These data suggest that a technique has been developed which produces high levels of curly top infection by field inoculations.

Yield losses were significant for both varieties in plots inoculated early with the severe isolate of curly top virus. Percent sucrose also was significantly lower. Plots of US H9A inoculated late with the severe isolate of virus had significantly lower gross sugar and root yields but percent sucrose was not affected. This response was not shown for plots of 868H4 with the same treatment. However, the US H9A plots with this treatment showed nematode damage in all four replications.

Replication error was high and resulted in the high LSD values for significance (Table 1). This was due mainly to scattered nematode infestations which caused damage in several plots and explains the yield inconsistencies reported and the high LSD's. The appearance of the test plot before harvest suggested that if plot differences could have been attributed only to curly top infection then significant differences between curly top strains and plants at the time of inoculation would have been more definite.

Table 1. Means and mean squares for effect of curly top on plants of two varieties inoculated at different stages of growth.

Varieties	Curly Top Isolate	Inocula- tion Date	Acre Yield			Curly Top Infection Percent	
			Gross Sugar	Beets	Sucrose		
			Pounds	Tons	Percent		
868H4	Check	Jun. 11	4,169	12.1	17.2	--	
		Jul. 20	4,251	12.6	16.8	--	
	MSI ^{1/}	Jun. 11	2,945	8.8	16.7	83	
		Jul. 20	3,922	11.4	17.2	40	
	SI ^{2/}	Jun. 11	717	2.3	14.9	86	
		Jul. 20	3,967	11.7	16.8	61	
	US H9A	Check	Jun. 11	4,730	13.8	17.1	--
			Jul. 20	4,623	13.5	17.0	--
		MSI	Jun. 11	3,409	10.3	16.3	82
			Jul. 20	4,955	14.5	17.0	58
SI		Jun. 11	762	2.5	14.2	91	
		Jul. 20	2,582	7.6	17.0	68	
LSD 5%			1,472	4.8	1.5	17.0	

Analysis of Variance

Source	d.f.	M E A N S Q U A R E S			d.f.	Curly Top Percent
		Gross Sugar	Beets Tons	Sucrose Percent		
Replication	3	16,171,417**	134.69**	1.07	3	63.33
Variety (A)	1	394,400	3.65	0.38	1	442.56
C.T. Strains (B)	2	25,553,326**	211.84**	7.87**	1	957.00*
Inoculation Stage (C)	1	19,100,372**	153.94**	10.37**	1	6,526.00**
A x B	2	2,253,829	19.94	0.13	1	5.44
A x C	1	367,325	3.81	0.67	1	195.00
B x C	2	6,488,483**	51.41**	7.09**	1	176.00
A x B x C	2	1,018,291	8.33	0.45	1	138.00
Error	33	1,168,275	9.54	1.11	21	133.00
	47				31	

^{1/}MSI = Moderately severe isolate of curly top virus.

^{2/}SI = Severe isolate.

* = 0.05

** = 0.01

Effects of Fumigation, Fertilizer, Variety and Crop Rotation on Yield, Sucrose and Purity of Sugarbeets

E. D. Whitney and I. O. Skoyen

Substantial increases in the use of soil fumigants such as methyl bromide and chloropicrin to control soilborne disease organisms and to increase yields raise questions of their potential for increasing yields of sugarbeets. For example, what is maximum sugar yield of a variety at different fertilizer levels and cropping rotations? How effective is fumigation for controlling root pruning organisms? Does fumigation cause responses in sugarbeet that effect purity? A three-year experiment is in progress to evaluate these and other questions. Results of the first year's testing are reported.

Materials and Methods: A factorial experiment was designed with three levels of nitrogen and two levels each of fumigation, crop rotation and varieties. The field design was a split-split plot with crop rotations as main plots, fumigations as sub-plots and variety times fertilizer treatment combinations as sub-sub-plots. The field arrangement was three blocks with two replications per block. All treatments were completely randomized within blocks or sub-plots.

The nitrogen fertilizer levels were 100, 180 and 260 lbs. per acre. Level one was applied preplant and included 50 lbs. of P_2O_5 and 25 lbs. of K_2O per acre. Levels two and three were sidedressed in increments of 80 lbs. each. Sidedress applications were made 9 weeks after planting to plots of both level two and level three. Six weeks later level three plots received a second sidedress application. The fertilizer shoes were run in all plots at the time selected plots were fertilized.

The fumigation (67% methyl bromide and 33% chloropicrin) was by commercial equipment at a rate of 370 lbs. per acre. A plastic tarp was laid over the treated area at the time of application. The fumigant was injected 8 inches deep and applied three months before planting. Soil temperatures were about 58 F at the 8 inch depth and moisture was 7-8%. The plastic tarps were removed after 72 hours.

Test varieties US H7A and US H9B were planted March 18, 1970 and thinned four weeks later. Weed control was maintained throughout the season. The beets following beets rotation was established by planting randomly selected plots in 1969. The unplanted plots were fallowed. The field was planted to barley in 1968.

Frequent short irrigations (by sprinkler system) were used to avoid runoff and as needed to maintain good growth. Following fumigation, ditches were made between blocks so that any runoff could be diverted to minimize contamination of treated areas.

Test plots were 4 rows wide and 27 feet long with 3 foot alleyways between plots. The test was harvested 6 1/2 months after planting. The roots from the center two rows of each plot were weighed and analyzed for percent sucrose, ppm NH_2 nitrogen, ppm sodium and ppm potassium.

Results and Discussion

The means for gross sugar yield, tons per acre, percent sucrose and the mean ppm for amino (NH_2) nitrogen, sodium (Na), potassium (K) and the impurity index are shown in Table 1. Interaction F-ratios and significance levels are also shown.

Main Effects: There were significant yield differences between treatments for all main effects (years, fumigations, fertilizer treatments and varieties) for tons per acre and gross sugar. Sucrose percent was significantly lower only for the high nitrogen treatment (260 lbs. of N). Consequently, gross sugar means mainly reflect differences in root yield.

The ppm NH_2 nitrogen in the roots from 1970 beet plots was significantly higher than roots from 1969-70 plots. Each increase in nitrogen (N) fertilizer significantly increased ppm NH_2 nitrogen in the roots. The ppm Na in roots from fumigated plots was significantly higher (1%) than for nonfumigated plots. US H9B had significantly lower Na than US H7A. Nitrogen fertilization significantly increased Na levels in the roots at 260 lbs. of N. The ppm K in the roots was significantly higher (1%) for 1970 plots, fumigation, US H7A and the 260 lb. rate of N. Impurity index was significant (5%) for the same variables as ppm K except for fertilizer treatments which showed significant increases in the impurity index for each increase of N.

There were no differences due to replications, indicating good test reliability.

Interactions: The comparison of years x fumigation (Yr x F) showed a significant interaction (1%) for gross sugar (Fig. 1). The yield increase due to fumigation was much greater in the 1969-70 plots than the 1970 plots.

A years x fertilizer levels (Yr x Ft) comparison showed an interaction due to increases in tons per acre that were proportionately greater for 1970 plots with the 100 lb. rate of N. (Fig. 2). The fumigation x fertilizer (F x Ft) interaction, Fig. 3, was nearly the same as for Yr x Ft. Yr x Ft and F x Ft interactions for gross sugar also were significant, Figs. 4 and 5. These interactions were of about the same magnitude as those for tons per acre. The similarity of the interactions for tons per acre and gross sugar reflects the small differences in percent sucrose. Crop rotation was as effective as fumigation for increasing root yields (Figs. 2 and 3) and gross sugar (Figs. 4 and 5).

There were significant interactions between years x fumigation x fertilizer levels (Yr x F x Ft) for both tons per acre and gross sugar (Figs. 6 and 7). This probably occurred because of the increased yield response to 180 lbs. of N for 1969-70 plots compared to the response to fertilizer levels for all other treatment combinations.

The comparison of years x fumigation x varieties (Yr x F x V) showed an interaction for gross sugar (Fig. 8). This was due to the significantly better performance of US H9B compared to US H7A in non-fumigated 1969-70 plots and also possibly in fumigated 1970 plots. A lower level of root damaging fungi in 1970 plots compared to that in 1969-70 beet plots may explain the yield increases, although tests for fungi that cause damping-off showed these to be low. Effects of increases in fungi levels on yields will be an important phase of the experiment during the next two years. The results shown in Fig. 8 indicate that for comparable treatments US H9B was superior to US H7A. This probably can be explained by the method used to select for virus yellows resistance in the C413 pollen parent of US H9B. During 5 successive selection cycles the ancestors of C413 were selected, on root size, root smoothness and freedom from effects of disease organisms. It is likely that this type of selection pressure would concentrate any factors for resistance or tolerance to root damaging fungi present in our research field soils. The pollen parent for US H7A, C264, has not been subjected to this selection pressure.

Tons per acre approached significance with $F=3.70$ (tabular $F .05$ required 3.94) for the Yr x F x V comparison (Table 1).

Analysis of percent sucrose showed an interaction for years x varieties x fertilizer levels (Yr x V x Ft) (Fig. 9). The interaction may be due to no difference in percent sucrose for US H7A in 1970 plots at any level of N. However, this is not clear because of the variability of US H7A for percent sucrose.

There were no interactions for NH_2 nitrogen content of the beet roots. This suggests that even at the 260 lbs. of N the plants had utilized nearly all available N by harvest.

Sodium levels in the roots showed significant interactions between fumigation x fertilizer levels (F x Ft), Fig. 10, and between years x varieties x fertilizer levels (Yr x V x Ft), Fig. 11. The data suggest the interaction of F x Ft is the result of a proportionately greater increase in the Na content of beets at 260 lbs. of N in fumigated plots compared to nonfumigated plots. The Yr x V x Ft interaction probably resulted from the proportionately greater increase in ppm Na in roots of US H7A from 1969-70 plots at 260 lbs. of N compared to that of the other rotation, variety and fertilizer combinations. US H7A showed higher Na in the roots than US H9B, though not necessarily significant, this trend has been observed before.

A significant interaction for years x fumigation (Yr x F) and for years x fertilizer treatments (Yr x Ft) occurred for K (Figs. 12 and 13). However, these interactions were inverse with the magnitude of the change for Yr x F greater in 1969-70 but for Yr x Ft it was greater in the 1970 rotation. Thus indicating that fumigation had the opposite effect of fertilizer on K.

Table 1. Means, significance levels and interactions for the characteristics measured over the four test variables.

Treatments	Levels	df	Acre Yield		Percent Sucrose	PPM			Impur- ity Index
			Pounds Gross Sugar	Tons Beets		NH ₂ N	Na	K	
Years (Yr)	1969-70	1	10,151	30.4	16.75	584	160	1934	674
	1970		11,494*	34.5*	16.70	646*	133	2138**	738*
Fumigation (F)	Non- Fum	1	10,269	30.3	17.01	618	119	1906	671
			11,379**	34.7**	16.44	611	175**	2166**	742*
Error A		5							
Varieties (V)	US H7A	1	10,345	31.1	16.67	611	172**	2113**	723*
	US H9B		11,300**	33.8**	16.78	619	121	1959	690
Fertilizer (Ft)	100		9,831a	29.0a	16.99a	515a	118a	1981a	621a
(lbs. nitrogen)	180	2	11,116b	33.0b	16.88a	607b	132a	2000a	685b
	260		11,522b	35.4c	16.31b	723c	190b	2127b	813c

Means followed by the same letter not significantly different hsd = .01

Interaction F-Ratios and Significance Levels

Yr x F	1	28.30**	2.37	4.65	1 ^d	4.68	10.33**	1.81
Error B	10							
V x Ft	1	1	1	3.17	1.76	2.26	1	1.12
Yr x V	1	1	1	1	1	1	1	1
F x V	1	1.47	1.30	1	2.24	1	1	1.15
Yr x F x V	1	6.02*	3.70	2.84	1	1	1	1
Yr x Ft	2	5.73**	3.95*	1.26	1.07	1.33	5.93**	1
F x Ft	2	7.51**	6.42**	1	1	3.90*	1	1
Yr x F x Ft	2	6.93**	6.95**	1	1	1.58	1	1
Yr x V x Ft	2	1	1	4.06*	1	4.39*	1	2.37
F x V x Ft	2	1	1	1	2.18	1	1	1.10
Yr x F x V x Ft	2	1	1	1	1	1	1	1

Error C 100

0.01**

0.05*

^d = less than one.

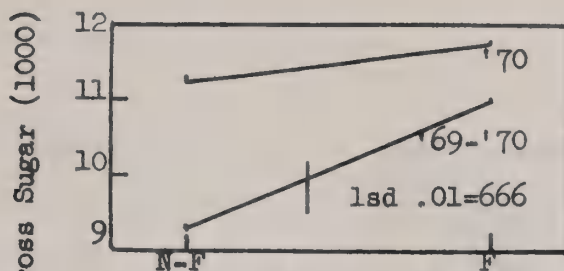


Fig. 1. Years x Fumigation

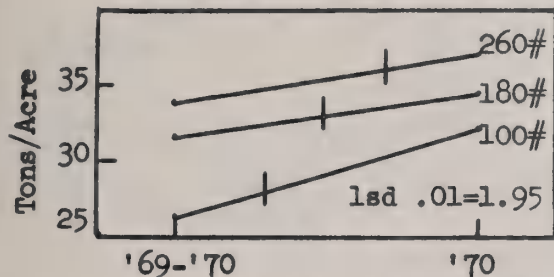


Fig. 2. Years x Fertilizer

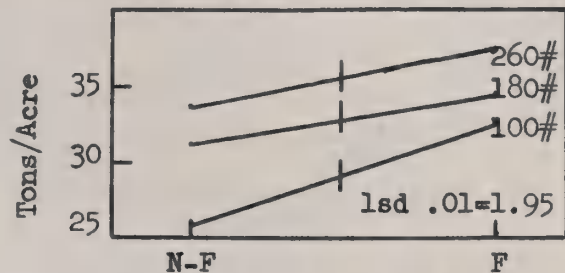


Fig. 3. Fumigation x Fertilizer

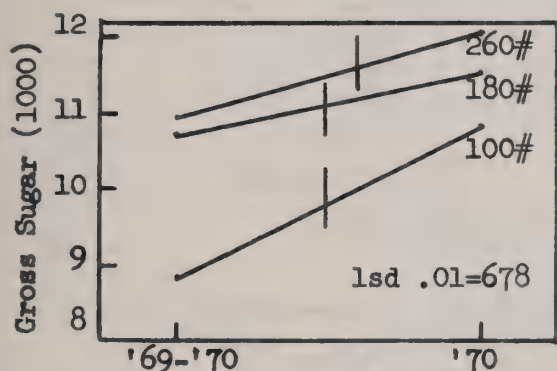


Fig. 4. Years x Fertilizer

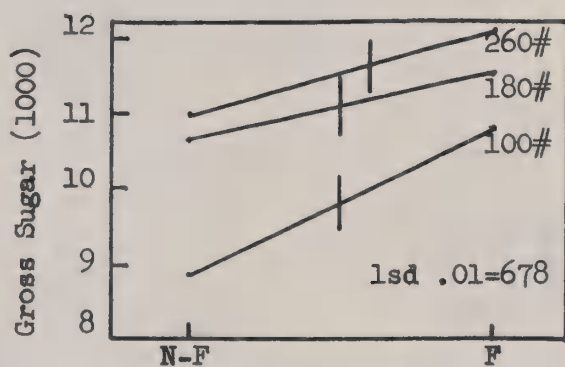


Fig. 5. Fumigation x Fertilizer

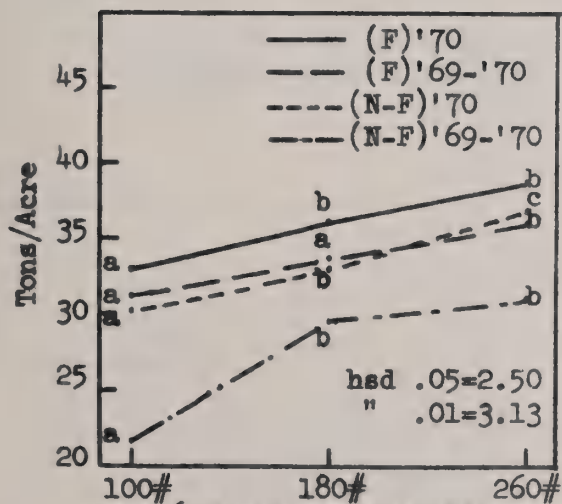


Fig. 6. Years x Fumigation
x Fertilizer

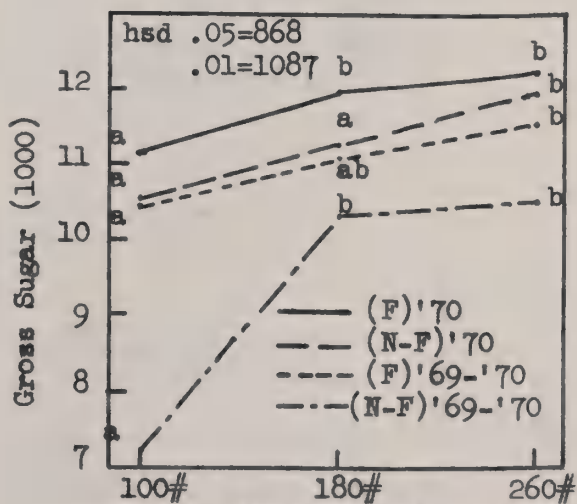
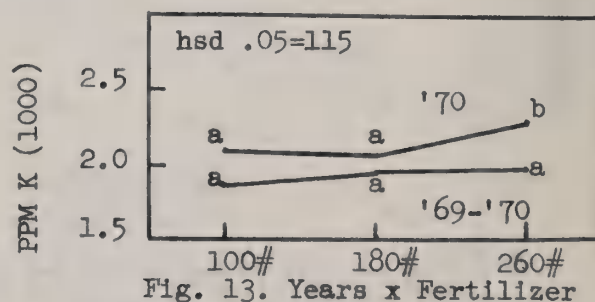
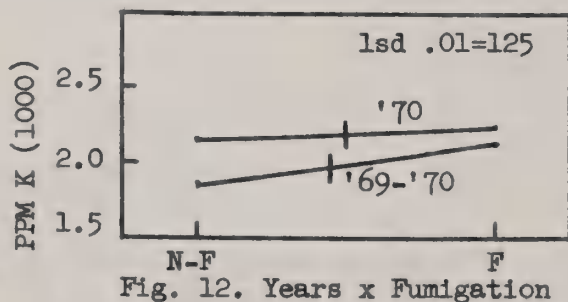
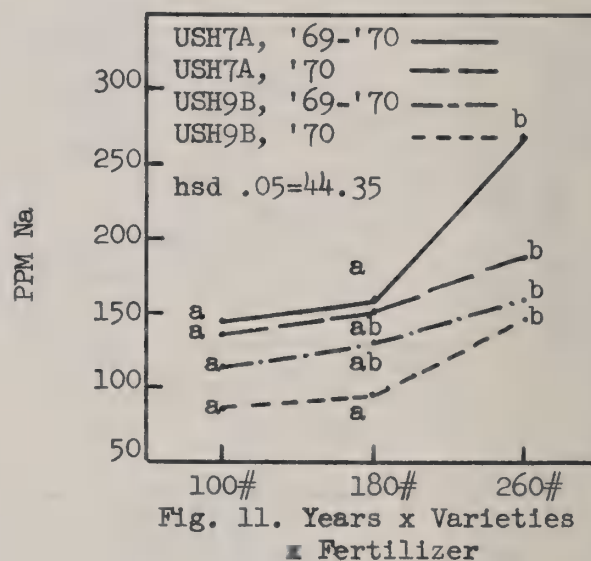
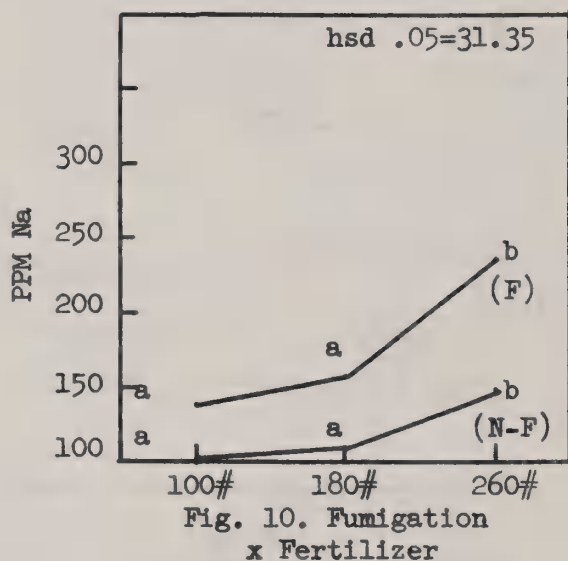
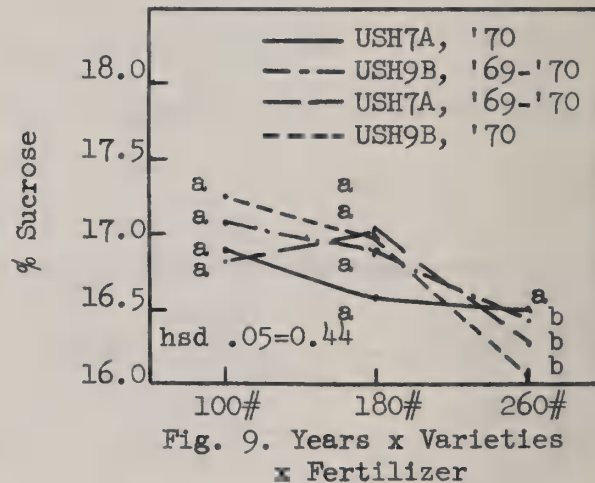
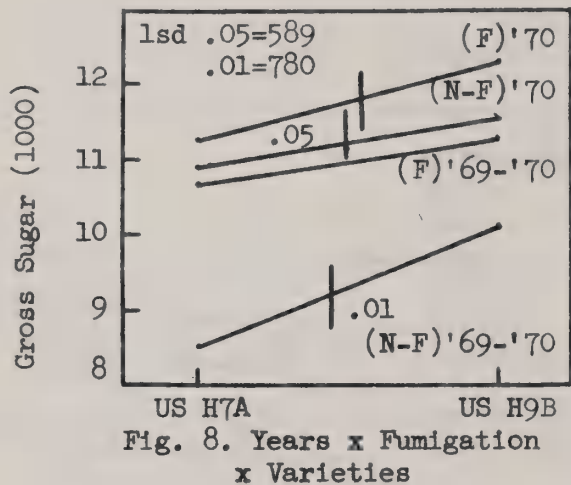


Fig. 7. Years x Fumigation
x Fertilizer



SUGARBEET RESEARCH

1970 Report

Section C

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CONTENTS

	Page
SUMMARY OF RESEARCH ACCOMPLISHMENTS	
Genetics and Breeding	C2
Plant Pathology	C4
Plant Physiology	C5
VARIETY TESTS, LOGAN AND FARMINGTON, UTAH, 1970 by G. K. Ryser and J. C. Theurer	C6
VARIETY TRIALS FOR CURLY TOP RESISTANCE by J. C. Theurer and D. L. Mumford	C41
STUDIES ON THE VARIATION OF PARTIAL MALE FERTILITY by J. C. Theurer and E. H. Ottley	C44
VIRUS INVESTIGATIONS by D. L. Mumford	
Curly Top Disease Nursery	C50
Correlation of Curly Top Evaluation in Greenhouse and Field	C50
Virulence of Curly Top Isolates from the Pacific Northwest	C51
RESPIRATION RATES OF SEVERAL SUGARBEET VARIETIES by R. W. Wyse	C54
EVALUATION OF WAX COATINGS FOR SUGARBEET STORAGE by R. W. Wyse	C55

SUMMARY OF RESEARCH ACCOMPLISHMENTS
Logan, Utah - 1970

Genetics and Breeding

Variety Tests

Nine different variety tests were conducted on the Utah State University North Farm at Logan, and on the Farmington, Utah farm in 1970. In one test at each location, a comparison was made between seven single crosses and part of the possible 3-way and 4-way hybrids having parents in common. On the average, the 3-way hybrids had higher gross sugar, tonnage, and sugar percentage than the single crosses and 4-way hybrids. Correlation coefficients of 4-way hybrid versus the average of the parental single crosses for yield, sugar percentage and impurity index were low and non-significant except for sugar percentage and impurity index at Farmington. This indicated one could not predict hybrid performance based on the average of the parental single crosses.

In a replicated test seven CMS single-cross hybrids showed significant differences in gross sugar and tonnage when compared with their reciprocal hybrids. However, with one exception, this could be explained by differences in stand. There were no significant differences for sugar by either LSD or "t" tests. There was no significant difference between reciprocals for impurity index, with one exception. (EL 31 X CT9) was 99 units lower in index than the reciprocal cross, which was also reflected in all of the impurity components of the index, i.e. amino N, Na, and K.

A transplant versus seeding planting of six varieties showed similar results to those of a similar study conducted in 1969. The transplants had the greatest initial seedling vigor in the field and were slightly, but not significantly, better in gross sugar, tonnage, and sugar percentage. Quality factors for the two types of planting were similar.

Comparison was made at both Logan and Farmington of five 3-way hybrids having 129 Rf as a pollinator with related 4-way hybrids. Addition of CT9 or A7113 (American Crystal CMS) to 129 Rf to form the single-cross pollinator for the 4-way hybrids increased gross sugar and tonnage over that of the comparable 3-way hybrid. Addition of EL 31 CMS as a parent decreased yield significantly. There was no difference between 3-way and 4-way hybrids for sucrose percentage.

In other variety tests of new single crosses, 3-way and pollen restorer hybrids, several were significantly better in yield and sugar percentage than currently used commercial check varieties. Hybrids with 0198 S parentage evidenced good general combining ability for yield.

L-19 hybrids showed superior combining ability for sugar percentage. These results are in agreement and confirm the performance of these lines in 1969 tests.

Variety Trials for Curly Top Resistance

Six single crosses and their reciprocals were planted in the curly top nursery and compared for disease reaction. The "t" tests showed no differences indicating that two or three backcrosses resulted in approximately the same equivalent degree of curly top resistance as the original male parent.

An evaluation of the curly top resistance of related 3-way and 4-way hybrids was also made in 1970. The addition of a resistant line to inbred parents of a 3-way hybrid (i.e. a 4-way hybrid with three parents in common to the 3-way) slightly increased resistance. Addition of a susceptible parent resulted in the 4-way being slightly more susceptible than the 3-way hybrid of similar parentage. The brief amount of data in the test suggests that one or two curly top susceptible lines can be used in 4-way hybrids without materially lowering the curly top resistance.

In another test, 15 double-cross hybrids and 7 of the single-cross parents of these hybrids were evaluated. In general the average of the single-cross parents were slightly higher than the actual curly top grade of the 4-way hybrids. The correlation coefficients between averages of the single-cross parents and respective 4-way hybrid was .70, which indicated that the most resistant and least resistant curly top 4-way hybrids could be predicted on the basis of their respective parental single-cross average.

Studies on Variation of Partial-Male Fertility

An extensive detailed study of the fertility of S_1 progenies of partial-fertile segregates from six related populations was conducted in 1970. Each flower on each branch of over 500 plants was carefully observed. A sample of anthers from every fifth flower was squashed on a slide in a drop of aceto-carmin dye and subsequently observed microscopically for the percentage of stainable pollen. Seed was harvested individually so as to note the exact placement of each seed on each plant relative to the fertility of the corresponding flower.

Considerable variation from flower to flower, branch to branch, and plant to plant was observed within the same population. Plants ranged from 100% male sterile to completely fertile with all degrees in between. Overall segregation of 266 completely male sterile to 232 plants showing some degree of stainable pollen, fit a 9:7 genetic ratio, indicating that fertility versus complete sterility was due to two genetic factors. General observation indicated that seed set is random and was not associated with the pollen condition of the flower. The genetics of partial-male fertile lines still remains obscure.

Linkage and Inheritance Studies

Several lines in the F_2 generation were planted in the fall of 1969 in a steckling plot in St. George, Utah. Due to problems in the steckling plot, insufficient numbers of plants were obtained to be meaningful, so the study must be repeated.

Crosses have been made with several mutants sent to us by Great Western Sugar Company. One mutant, a bright yellow leaf was crossed with SLC 129 and found to be inherited as a simple recessive. As part of the research assistantship, linkage studies have been initiated between an annual Rf gene and other genetic markers known in the sugarbeet.

Studies with Various Sources of Male Sterility

Male-sterile segregates have been isolated from an open-pollinated variety provided by Great Western Sugar Company and crosses have been made to study the inheritance of this source, which is thought to be inherited as a genetic dominant.

Plants from permanent seed of an open-pollinated variety which Dr. F. V. Owen received from Dr. Sydney Ellerton several years ago have been crossed to CT5 a₁a₁. Ten F_2 populations have been classified and the preliminary data suggest two genes are involved in the inheritance of this source of sterility.

Plant Pathology

A curly top disease nursery of 2,279 rows was evaluated in 1970. Percentage infection and average grade of each row was distributed to all nursery participants.

A highly significant correlation coefficient was obtained between results of field and greenhouse evaluation of 291 sugarbeet lines. This supports the generally held assumption that evaluation for curly top resistance can be successfully accomplished in the greenhouse.

The virulence of curly top virus isolates collected in the Pacific Northwest was compared to strain 11 from Idaho and isolate 66-10 from Utah. Most isolates were more virulent than strain 11 and two approached 66-10 in virulence.

Numerous attempts have been made at obtaining a preparation of curly top virus of sufficient purity to determine its morphology with the electron microscope. Although virus-like particles have been observed, some doubt still exists as to the size and shape of the virus. Several new techniques are currently being employed to further purify the virus.

Plant Physiology

An extensive study of the storage characteristics of eight varieties was begun in an attempt to develop a technique for rapidly determining the storage potential of a variety at harvest. A 2.6 fold range was found in the respiration rate of whole beets. These differences were not correlated to surface area, which indicates a physiological basis for the variation. Similar variation between varieties was found in the accumulation of raffinose and invert in short term storage. Enzyme activities related to sucrose degradation and raffinose synthesis correlated closely with invert and raffinose accumulation. Detailed chemical analyses of the stored varieties are currently being made.

Wax coatings were evaluated as a potential means of reducing desiccation and/or respiration on the surface of commercial storage piles. Desiccation was reduced by these coatings at both 5 and 23 C, but respiration was significantly reduced only at 23 C. Commercial testing appears to be in order.

Sucrose synthetase was purified approximately 100 fold to a pure protein. Purity was verified by DEAE - chromatography and acrylamide gel electrophoresis. Specificity of the enzyme for sugar nucleotides showed that UDP- galactose, UDP- N - acetylglucose amine, UDP - xylose, UDP- glucuronic acid, UDP- mannose were utilized.

A study of the biochemical pathway of sucrose degradation and raffinose synthesis were begun. Specific inhibitors are being studied for possible use in blocking the synthesis of raffinose after the pathway has been elucidated.

Differences in the respiration rates of individual roots indicated that small roots respire faster than large roots at 23 C but not at 5 C. Further studies showed that at 23 C diffusive resistance or surface area played a predominant role in regulating respiration rates. However, at 4 C physiological factors predominated. Mitochondrial studies indicated no significant differences in the P/O or R.C. ratios between individual roots.

Variety Tests, Logan and Farmington, Utah, 1970

George K. Ryser and J. C. Theurer

SOIL TYPES: Silty loam on the University North Farm at Logan and sandy loam on the Farmington Farm.

PREVIOUS CROPS: The area planted on the North Farm consisted of three adjacent sections of land numbered 8, 9, and 10. In 1969 section 8 was planted in grain and 9 and 10 were fallowed. In 1968, 8 and 9 were fallowed and 10 was planted in grain. At the Farmington Farm the area was planted part in tomatoes and part in potatoes in 1969.

FERTILIZER: Both farms received 500 pounds per acre of 24-20-0, harrowed in before planting.

PLANTING DATES: Farmington Farm was planted April 17, 1970. North Farm was planted May 18, 1970.

THINNING DATES: North Farm June 15 to 18th, 1970. Farmington Farm May 26 to 29th, 1970.

IRRIGATIONS: North Farm was sprinkled after planting, after thinning, and on a weekly schedule until two weeks before harvest. Farmington was furrow irrigated approximately at weekly intervals, as needed, to keep the field on the damp side throughout the season until two weeks before harvest.

HARVEST DATES AND PROCEDURES: North Farm was harvested October 29 to November 5, 1970. Farmington Farm was harvested October 14 through 16, 1970.

Tops were removed with a rotobearer and scalped with tractor-mounted scalping tools supplemented by long-handled hoe trimming to assure a complete topping job. Beets in plots were counted when put into the weighing basket on the harvester. A ten-beet sample was taken at random from the harvester table from each row of the two-row plots for sugar analysis, and all beets in the plot were weighed to determine root yield.

EXPERIMENTAL DESIGN: Test 1 was planted at Farmington, Utah in two-row plots with 36 entries in randomized block design (RBD) with six replications.

Test 2 was planted on the North Farm, Logan, Utah, with 30 entries in a RBD design of six replications.

Test 3 was planted at Farmington, Utah, in a split-plot RBD design with seven paired comparisons of reciprocal crosses.

Test 4 was planted on the North Farm, Logan, Utah, in 4-row plots and 5 replications. One-month old and two-week old seedlings of four varieties were transplanted for comparison with an adjacent seed planting of each variety. Only the two center rows of each plot were harvested and the data was analyzed as a 4 X 3 factorial in RBD.

Test 5 was planted at both locations with 28 entries to compare 3-way hybrids versus 4-way hybrids. It was analyzed as a RBD with 28 entries and 6 replications. The data for three groups of females crossed with the same five male parents were also analyzed as 2 X 3 X 5 factorial.

Test 6 was made up of 40 entries planted at the North Farm, Logan, Utah, in RBD design with 5 replications.

Test 7 was planted at Farmington, Utah, and had 38 entries in 5 replications of a RBD design.

Test 8 was planted at the North Farm, Logan, Utah, and had 38 entries in 6 replications of a RBD design.

Test 9. This test of 70 entries was planted at the North Farm, Logan, Utah, in a RBD design with 6 replications.

Variety Test 1

This test was made up of seven single crosses, ten 3-way hybrids, fifteen 4-way hybrids and three check varieties and was grown at Farmington, Utah. The object of the test was to compare single, 3-way, and 4-way hybrids from the same inbred lines and determine if the parental single-cross means would give a prediction of the 4-way hybrid yield.

The analysis of variance shows highly significant differences between varieties in all eight variables measured (Table 1).

An overall comparison of the means of the single crosses with the 3 and 4-way hybrids showed no significance for gross sugar, although the 3-way and 4-way hybrids had higher yields. The single cross (133 CMS X 201 Rf) was the highest in yield in the test. To a large degree the poor stand of (A7112 X NB-1) was the cause of the lower average single-cross yield. The 3-way hybrids were significantly better than the single crosses in tons per acre and percent sugar. The 3-way hybrids were also superior to the 4-way hybrids in percent sugar. There was no significant differences in impurity index between the average of the three hybrid groups.

The performance of eleven 4-way hybrids was compared with the average of their two parental single crosses (Table 2). Correlation values for gross sugar and tons per acre were negative and non-significant. For percent sugar and index the overall positive correlations of .73 and .74 were significant at the 1% point. These data suggest that the sugar percentage and impurity index could be predicted from the mean single-cross performance of the parents. Conversely, gross sugar and tonnage of 4-way hybrids could not be estimated in this manner.

The single-cross check UI #7 was equal to the best of the entries in the test and in comparison US 22/3 check was among the lower yielding hybrids.

Variety Test 2

This test was planted at Logan and is similar to test 1 at Farmington but with six less entries (five 3-way hybrids and the Amalgamated check variety).

The analysis of variance (Table 3) showed highly significant differences between varieties in all eight variables except percent sugar. UI single cross #7 had higher gross sugar and tonnage than any of the experimental hybrids in the test, and all but nine entries exceeded the US 22/3 check variety for yield.

Comparison of the mean performance of the single crosses with that of the 3-way and 4-way hybrids showed significance for gross sugar and tons per acre (Table 3A). The 3-way hybrids had higher yield than either the single crosses or the double crosses. The double crosses also exceeded the yield of the single-cross hybrids. There was no significance between the three types of hybrids for sugar percentage or impurity index.

The performance of eleven of the 4-way hybrids was compared with the average performance of their two respective parental single crosses (Table 4). Correlation coefficients for gross sugar, tonnage, sugar percentage and index were all low and non-significant. The r values were higher for sugar percentage and index than for yield factors but contrasted greatly with the significant r values found at Farmington for these same hybrid comparisons (Table 2). These data indicate that the performance of double crosses cannot be predicted from mean parental single-cross performance.

The "t" tests between each 4-way hybrid and their respective single-cross means showed non-significance for gross sugar and tonnage except for comparisons involving the single cross (AC CMS X NB-1). This single cross had a very poor stand of 28 beets compared to the test mean of 72 beets per plot. This factor probably accounted for the large differences that were observed. The "t" tests for gross sugar and impurity index showed no significant differences.

Variety Test 3

It is generally assumed that cytoplasmic male-sterile (BC_2 and BC_3) and equivalent type-0 pollinators give the same performance in hybrid combinations. However, in many instances in seed plots the male-sterile line appears to flower slightly earlier and to be more vigorous than the pollinator. This test was established to compare differences between seven reciprocal CMS single-cross hybrids.

The analysis of variance shows significance for all eight variables studied (Table 5). Single crosses (EL 32 X CT 9) and (133 X NB-1) had the highest gross sugar and tonnage. However, the yield of the UI #7 single-cross check was higher in tonnage and gross sugar than either of these single crosses. (EL 31 X 133) crosses averaged the highest sugar percentage and (NB-1 X 128) crosses had the lowest impurity index.

There were significant differences between reciprocals for each pair of crosses for gross sugar and tonnage. However, with the exception of the (CT9 X 133) crosses, the higher yielding cross also had the greatest number of beets. Thus the differences may reflect stand differences rather than true reciprocal effects.

There was no significant differences between reciprocals for sugar percentage when tested by either the test L.S.D. or by "t" tests of differences between the means of each pair of single crosses. (CT9 X 133) crosses had identical sugar percentages and the greatest spread was .43% for the (NB-1 X 133) crosses.

Some of the reciprocals were extremely close in their index values, and with the exception of one comparison, all differences were non-significant. (EL 31 X CT9) was 99 units lower in the index value than was the reciprocal (CT9 X EL 31). This same difference was noted for the three impurity factors amino N, Na, and K.

Variety Test 4

With recent interest in the possibility of transplanting sugarbeets to stand rather than seeding and thinning, we initiated a study in 1969 (see page C5 of 1969 report) to evaluate this possibility in our area. Inasmuch as the month-old 1969 transplants showed considerable sprangling of roots at harvest, it was decided to see if younger-aged transplants would result in a reduction in sprangling and still maintain higher yield. Six varieties were planted in 3 cm X 10 cm Japanese paper pots in large wooden flats in the greenhouse on April 16, 1970, and a duplicate planting was made two weeks later on May 1. Considerable "damping off" occurred in planting #1 because of the failure to sterilize the soil and treat the seed before planting.

These plants were grown in a 50:50 mixture of sandy soil and peat in the greenhouse under gro-lux lamps and were irrigated with 1/2 N Hoagland solution. Due to a misunderstanding, the first planting received Hoagland solution only once per week for the first 2 1/2 weeks with both plantings receiving nutrient on a daily basis thereafter. This resulted in little difference in the stage of seedling development between the two planting dates, by May 19th, when they were transplanted into field plots. Immediately after transplanting, the field was thoroughly soaked by sprinkler irrigation.

RESULTS

The results of this study were essentially the same as observed in 1969. The transplanted plots showed more rapid growth and a larger canopy of foliage than the seeded plots during the first two months of field growth as was observed in the 1969 transplant test.

At harvest both transplanted units had sprangled roots, but the second date transplants (2-week old) showed less severe sprangling. A further problem of poor stands was evident in the first transplant units. The roots in some of the varieties of this unit had rhizoctonia lesions, which no doubt accounted for poor stands and lower yields.

The analysis of variance showed significant differences for treatments gross sugar, tons per acre, and the impurity index (Table 6). The varieties showed meaningful differences for gross sugar, tonnage, sodium, and potassium.

The second transplanting had higher tonnage and gross sugar than the seed plots on the average; but these differences were not as striking as observed in 1969 (Table 7). This could be due to the 2-week age as compared with the month-old seedlings used last year. The seeded plots were significantly better than transplant #1 plots. However, as pointed out previously, the lack of proper fertilization, the disease problem, and resultant poor stands make this comparison invalid.

There was no significant difference in sucrose percentage even though transplant #2 units averaged slightly higher for this variable. Transplant #2 units also showed lower impurity index values, as well as lower PPM amino N, Na, and K, but none of the differences between transplants versus seeding were significant (Table 8).

Variety Test 5

This variety test was set up to compare the performance of 3-way and related 4-way hybrids and was planted at both Logan and Farmington. Part of the test was orthogonal with 15 varieties - three common females crossed to five common males. This part of the test was analyzed as a factorial for the combined locations.

RESULTS

The analysis of variance is given in Table 9. With the exception of K, there was significant differences between the locations for all variables. The gross sugar, tonnage, and sugar percentage were higher and the impurity index lower in the Farmington planting. The females were considerably different for all variables except amino N. The male parents showed significance for differences in all variables except sucrose.

At Logan, the check variety UI #7 had the highest tonnage and gross sugar (Table 14). The single cross (EL 32 X 129 Rf) was the pollen parent of 4-way hybrids having the lowest gross sugar and tonnage. Part of this difference no doubt can be attributed to poor stand for the varieties having this pollen parent. (A7113 X 129 Rf) was pollen parent of the highest yielding 4-way hybrids.

None of the hybrids were significantly better than the check varieties for sugar percentage. The 4-way hybrid (code 3) (UI 11863 X CT7) X (133 X 129 Rf) had the highest sugar percentage. The other 3-way hybrids exceeded their respective 4-way hybrids having (UI 11863 X CT7) or (133 X 712) as female parents, for sugar percentage. The 4-way hybrids having other single crosses as female parents were in general better than their comparable 3-way hybrid for this variable.

(UI 11863 X CT7) X (0v X 129 Rf), code 6, had the lowest impurity index.

The UI #7 check was again the highest yielding variety at Farmington. The inbreds CT9 and A7113 in 4-way hybrids resulted in an increase in gross sugar and tonnage while inbred EL 32 as a parent resulted in a decrease in yield compared to the respective 3-way cross. Hybrids (UI 11863 X CT7) X (CT9 X 129 Rf) and (UI 11863 X CT7) X (0v X 129 Rf) had the highest sugar percentage at this location. The latter hybrid had the lowest impurity index, which is in agreement with the results of the Logan planting of this test.

Data for combined locations for an orthoganal set of hybrids is given in table 12. The females (UI #7) and (133 X 712) averaged significantly higher gross sugar than the female (UI 11863 X CT7). All females were significantly different for tonnage. (UI 11863 X CT7) was significantly better than the other two females for sugar percentage and impurity index.

The addition of CT9 or A7113 to the pollinator line in these hybrids increased the gross sugar and tonnage but not significantly. Addition of EL 32 to hybrids on the average decreased gross sugar and tonnage. There was no difference in the sugar percentage of the male parents. The (CT9 X 129 Rf) and (0v X 129 Rf) pollinators were about equal to the 129 Rf pollinator. The other two males were significantly poorer in quality as indicated by the higher index values.

The data of this study indicate that the combining ability of the respective inbred lines should be the governing factor as to whether a 3-way or 4-way hybrid will exhibit the best performance.

Variety Test 6

The single crosses in this test were composed of lines from diverse sources, some developed at Salt Lake or Logan and some developed outside of the intermountain area. A7113 and A7112 are CMS lines from American Crystal Sugar Company. EL 32, A7134 (SP 6322-0 LSR) and A7135 (02 clone from 61 B28-01 LSR) were received from Dr. George Hogaboam from East Lansing.

The four highest yielding single crosses (codes 8, 27, 31,28) were significantly higher in gross sugar than the best check variety UI #7 (Table 13). Three of these hybrids had an Ovana parent that tends to increase yield. The pollinator 0198 S which was a parent of the best hybrids tested in 1969 again expressed its combining ability for high yield. With the exception of two hybrids, all others had higher gross sugar than the Logan, Amalgamated commercial, and US 22/3 checks with 12 hybrids being significantly superior for this factor.

The single cross (CT9 X Ov.1) had the highest sugar percentage. This variety was the only one significantly better than any of the checks. Hybrids with L-19 (codes 35 and 36) again demonstrated combining ability for high sugar. CT8 and A7134 were parents of hybrids that in general were the lowest in sugar percentage.

Variety Test 7

This test consists mostly of new pollen-restorer hybrids. In addition, five entries which showed high yield or high sugar in 1969 were included as check varieties.

It was of interest that the highest yielding entry was (133 X 129) X A7134, the pollinator being the leaf-spot resistant line SP 6322-0. However, this hybrid was not significantly superior to UI #7 commercial hybrid or nine other entries. The high yielding checks (codes 34,35) were among the top varieties, indicating again the high combining ability of the 0198 S pollinator for yield. Three of the seven highest yielding entries had (A7113 X 129 Rf) as a pollen parent. The high yielding check (133 X 0198 S) also had the second highest sugar percentage of the varieties in the test. The check (129 X L-19) had a sugar percentage of 17.94 and was significantly better for sugar percentage than all other entries. The other hybrid having L-19 as a parent (code 33) was also high in sucrose percentage.

The commercial varieties, UI Hybrid #7 and the Amalgamated check, had the lowest impurity index in the test. They were significantly better in quality than all but four entries (codes 3, 7, 8, 32). The restorer hybrids having the best quality as indicated by the impurity index were (A7112 X CT9) X (133 X 129 Rf), (Ov X CT5B) X (133 X 129 Rf), and (133 X 22.005) X (CT9 X 129 Rf).

Variety Test 8

The single crosses in this test were produced in 1968, but most of them were not tested in 1969 due to limited land area. The Amalgamated check varieties were the currently used commercial hybrids AH-3 and AH-3A.

Sixteen hybrids exceeded the check variety in gross sugar, but only one (code 34) was significantly superior. The pollinator designated as (133 X m'm') which was derived from SLC 133 crossed to a Russian monogerm, contributed to high yield. (Ov CMS X 29.005) had the highest tonnage, significantly exceeding all but three varieties for this trait. None of the experimental hybrids was significantly better than the AH-3 check (code 37) for tonnage.

Hybrid (128 CMS X L-13) had the highest sugar percentage in the test. Twelve varieties (codes 1,3,6,8,11,20,21,23,31,32,34, and 36) were significantly better in sugar percentage than the best check AH-3.

Hybrids having the highest sugar percentage (code 23 and 34) also had the lowest impurity index.

Variety Test 9

This test consisted of 68 3-way hybrids in comparison with the two Amalgamated Sugar Company commercial varieties AH 3 and AH 3A.

The 0198 S pollinator line showed excellent combining ability in this test as indicated by the high yield of gross sugar and tons of beets per acre (Table 16). In certain combinations the L-19 pollinator was also among the varieties having the highest gross sugar. Twenty-eight hybrids were significantly superior to the best commercial check AH 3, for gross sugar. Eleven hybrids had significantly higher tonnage than this check.

Hybrids having high sugar percentage also had L-19 as a male parent. This again demonstrates good combining ability for this inbred with respect to sugar percentage. Line 0461 S also contributed to high sugar percentage, but yield of hybrids having this line as a parent were among the lowest in the test. Twenty-eight hybrids were significantly better than AH 3 for this character. Lines high in sugar also had the lowest impurity index values. Six hybrids had better quality than AH 3 as shown by their lower impurity index.

Table 1 . Performance prediction variety trial, Farmington, Utah, 1970. (36 entries, 6 reps)

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets			Index	Amino N	Na	K	
1	A7112 X EL 31	8,518	25.25		16.84	392	196	202	1,583	54
2	0v CMS X EL 31	10,279	32.01		16.08	496	298	270	1,623	64
3	A7112 X NB-1	4,727	14.49		16.27	428	193	216	1,714	23
4	CT9 CMS X 201 Rf	10,138	31.42		16.15	455	205	162	1,886	68
5	CT9 CMS X 129 Rf	9,888	30.93		15.97	401	191	172	1,556	69
6	133 CMS X 129 Rf	8,052	24.17		16.73	340	165	227	1,301	49
7	133 CMS X 201 Rf	10,744	32.86		16.31	374	165	198	1,499	59
	Mean of single crosses	8,906	27.30		16.34	412	202	209	1,595	55
8	0v CMS X (CT9 X 201 Rf)	9,287	28.87		16.12	451	225	182	1,739	65
9	NB-1 CMS X (CT9 X 201 Rf)	9,060	28.08		16.12	428	204	195	1,669	59
10	133 CMS X (CT9 X 201 Rf)	9,583	30.11		15.92	390	177	237	1,455	66
11	0v CMS X (CT9 X 129 Rf)	8,651	28.18		15.40	478	222	260	1,691	68
12	133 CMS X (CT9 X 129 Rf)	8,259	27.25		15.18	491	214	326	1,666	62
13	0v CMS X (133 X 201 Rf)	9,232	28.90		15.96	384	145	235	1,542	70
14	NB-1 CMS X (133 X 201 Rf)	9,153	29.08		15.76	370	159	252	1,351	63
15	CT9 CMS X (133 X 201 Rf)	10,128	32.66		15.50	510	225	242	1,905	69
16	0v CMS X (133 X 129 Rf)	8,534	25.97		16.57	439	248	207	1,605	64
18	CT9 CMS X (133 X 129 Rf)	9,092	28.82		15.87	470	257	252	1,582	64
	Mean of three-way crosses	9,098	28.79		15.84	441	212	243	1,623	65
19	(A7112 X EL 31) X (CT9 X 201 Rf)	9,729	29.29		16.65	461	301	162	1,622	60
20	(A7112 X EL 31) X (133 X 201 Rf)	9,380	27.90		16.80	356	187	186	1,390	73
21	(A7112 X EL 31) X (133 X 129 Rf)	9,524	28.41		16.76	405	240	200	1,484	71
22	(0v CMS X EL 31) X (CT9 X 201 Rf)	9,521	30.26		15.76	407	293	228	1,731	70
23	(0v CMS X EL 31) X (CT9 X 129 Rf)	9,425	29.54		15.97	404	220	182	1,428	72
24	(0v CMS X EL 31) X (133 X 201 Rf)	8,721	27.61		15.82	416	202	251	1,467	71
25	(0v CMS X EL 31) X (133 X 129 Rf)	8,685	26.74		16.27	393	217	227	1,364	67
26	(A7112 X NB-1) X (CT9 X 201 Rf)	8,813	27.87		15.81	451	211	202	1,732	65
27	(A7112 X NB-1) X (CT9 X 129 Rf)	9,667	29.14		16.59	457	262	202	1,708	72
28	(A7112 X NB-1) X (133 X 201 Rf)	9,028	27.41		16.51	410	203	248	1,546	71

Table 1 . continued

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons	Beets		Index	Amino N	Na	K	
29	(A7112 X NB-1) X (133 X 129 Rf)	8,991	27.15		16.55	349	145	272	1,345	73
30	(Ov CMS X NB-1) X (CT9 X 201 Rf)	9,417	29.29		16.13	392	197	185	1,479	66
31	(Ov CMS X NB-1) X (CT9 X 129 Rf)	8,600	26.20		16.45	377	190	208	1,421	66
32	(Ov CMS X NB-1) X (133 X 201 Rf)	8,740	27.66		15.87	467	248	258	1,589	62
33	(Ov CMS X NB-1) X (133 X 129 Rf)	9,025	27.77		16.30	482	301	261	1,566	60
	Mean of four-way crosses	9,151	28.16		16.28	423	248	216	1,524	68
34	UI Hybrid #7 check	10,557	31.81		16.61	365	175	203	1,440	71
35	US 22/3 check	8,612	26.61		16.18	486	267	226	1,742	70
36	Amalgamated commercial check	9,575	29.34		16.35	320	136	158	1,326	72
	Mean of all varieties	9,121	28.26		16.16	425	214	220	1,568	66
	S. E. of mean	545	1.67		.25	37	36	26	89	3
	L.S.D. 5% point	1,068	3.27		.69	103	100	72	247	8
	Calculated F	6.65**	7.01**		2.73**	2.02**	1.54*	2.04**	3.01**	17.19**

* Significant at 5% level

** Significant at 1% level

Table 2 . Means of parent single cross versus four-way hybrids, Test 1, Farmington, Utah, 1970.

Four-way crosses	Gross Sugar		Tons/Acre		% Sugar		Impurity Index	
	Parents	Cross	Parents	Cross	Parents	Cross	Parents	Cross
(A7112 X EL 31) X (CT9 X 201 Rf)	9,328	9,729	28.34	29.29	16.49	16.65	424	461
(A7112 X EL 31) X (133 X 201 Rf)	9,631	9,380	29.06	27.90	16.58	16.80	383	356
(A7112 X EL 31) X (133 X 129 Rf)	8,285	9,524	24.71	28.41	16.79	16.76	366	405
(Ov CMS X EL 31) X (CT9 X 201 Rf)	10,209	9,521	31.72	30.26	16.12	15.76	476	521
(Ov CMS X EL 31) X (CT9 X 129 Rf)	10,084	9,425	31.47	29.54	16.03	15.97	449	404
(Ov CMS X EL 31) X (133 X 201 Rf)	10,512	8,721	32.44	27.61	16.20	15.82	435	416
(Ov CMS X EL 31) X (133 X 129 Rf)	9,166	8,685	28.09	26.74	16.41	16.27	418	393
	r = -.2542		r = .2822		r = .9102**		r = .7043*	
(A7112 X NB-1) X (CT9 X 201 Rf)					16.21	15.81	442	451
(A7112 X NB-1) X (CT9 X 129 Rf)					16.12	16.59	420	457
(A7112 X NB-1) X (133 X 201 Rf)					16.29	16.51	401	410
(A7112 X NB-1) X (133 X 129 Rf)					16.50	16.55	384	349
			overall		r = .7345**		r = .7395**	

* Significant at 5% level

** Significant at 1% level

Table 3 . Performance prediction variety trial, Logan, Utah, 1970. (30 entries, 6 reps)

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons	Beets		Index	Amino N	Na	K	
29	UI Hybrid #7 check	6,606	24.71		13.39	739	529	234	1,511	81
20	(Ov CMS X EL 31) X (133 X 129 Rf)	6,591	23.70		13.89	717	495	273	1,622	78
18	(Ov CMS X EL 31) X (CT9 X 129 Rf)	6,591	23.47		14.04	744	503	236	1,840	79
9	Ov CMS X (CT9 X 129 Rf)	6,492	23.26		13.93	660	428	199	1,691	79
14	(A7112 X EL 31) X (133 X 129 Rf)	6,465	22.77		14.22	702	517	245	1,575	75
21	(A7112 X NB-1) X (CT9 X 201 Rf)	6,425	22.83		14.07	676	404	254	1,829	76
13	CT9 CMS X (133 X 129 Rf)	6,404	23.55		13.55	662	403	254	1,627	72
22	(A7112 X NB-1) X (CT9 X 129 Rf)	6,353	22.62		14.03	679	428	303	1,675	78
28	(Ov CMS X NB-1) X (133 X 129 Rf)	6,320	22.62		13.98	701	493	267	1,571	71
25	(Ov CMS X NB-1) X (CT9 X 201 Rf)	6,295	22.41		14.03	727	487	206	1,844	78
24	(A7112 X NB-1) X (133 X 129 Rf)	6,247	22.54		13.84	638	394	317	1,503	73
5	CT9 CMS X 129 Rf	6,217	22.42		13.88	654	403	200	1,735	74
12	Ov CMS X (133 X 129 Rf)	6,177	22.67		13.60	706	444	269	1,683	74
1	A7112 CMS X EL 31	6,094	22.18		13.67	785	533	233	1,824	62
23	(A7112 CMS X NB-1) X (133 X 201 Rf)	6,077	21.82		13.90	691	434	301	1,691	76
26	(Ov CMS X NB-1) X (CT9 X 129 Rf)	6,068	21.77		13.90	709	486	243	1,645	74
11	CT9 CMS X (133 X 201 Rf)	6,034	22.72		13.23	717	376	262	1,904	71
8	Ov CMS X (CT9 X 201 Rf)	6,022	21.95		13.72	718	445	211	1,861	78
10	Ov CMS X (133 X 201 Rf)	5,994	22.08		13.57	732	472	226	1,761	78
15	(A7112 CMS X EL 31) X (133 X 201 Rf)	5,967	21.49		13.92	682	437	243	1,681	75
30	US 22/3 check	5,866	21.26		13.81	711	454	250	1,747	78
2	Ov CMS X EL 31	5,802	21.33		13.57	766	541	239	1,655	66
17	(Ov CMS X EL 31) X (CT9 X 201 Rf)	5,790	21.41		13.52	781	475	272	1,937	72
6	133 CMS X 129 Rf	5,590	20.00		13.96	660	437	241	1,587	55
4	CT9 CMS X 201 Rf	5,552	20.18		13.73	690	372	209	1,974	72

Table 3 . continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
					Index	Amino N	Na	K	
16	(A7112 CMS X EL 31) X (CT9 X 201 Rf)	Gross Sugar	Tons Beets						
19	(0v CMS X EL 31) X (133 X 201 Rf)	5,438	20.33	13.39	738	447	267	1,785	74
7	133 CMS X 201 Rf	5,426	19.69	13.74	691	451	284	1,594	71
27	(0v CMS X NB-1) X (133 X 201 Rf)	4,926	18.40	13.36	656	416	255	1,464	66
3	A7112 CMS X NB-1	4,657	19.15	12.38	739	431	256	1,624	71
		4,374	15.90	13.72	838	552	282	1,989	28
Mean of all varieties									
S. E. of Mean		5,962	21.71	13.72	710	456	251	1,714	71
L.S.D. (5% point)		293	0.96	0.29	29	26	15	74	2
C.V. &		811	2.66	NS	81	72	40	205	6
Calculated F		12.03	10.83	5.20	10.13	13.87	14.24	10.62	8.32
		3.63**	3.48**	NS	2.30**	3.63**	4.25**	3.57**	16.88**

** Significant at 1% level

Table 3A. Means of single cross, 3-way and 4-way hybrid groups in Test 2, Logan, Utah, 1970.

	Acre Yield		Percent Sugar	PPM				Beet Count
				Index	Amino N	Na	K	
Mean of single crosses	Gross Sugar	Tons Beets						
Mean of 3-way crosses	5,522	20.05	13.70	721	465	237	1,747	60
Mean of 4-way crosses	6,187	22.71	13.60	699	428	237	1,755	75
	6,047	21.91	13.79	708	459	264	1,694	75

Table 4. Comparison of mean parental single cross and 4-way hybrid performance for seven entries in test 2 at Logan, Utah, 1970.

Double-Cross Description	Acre Yield				Percent Sugar				Impurity Index	
	Gross		Tons		Single		4-way		Single	4-way
	Crosses	Crosses	Crosses	Crosses	Crosses	Crosses	Crosses	Crosses		
(AC CMS X EL 31) X(133 X 129Rf)	5,842	6,465	21.09	22.77	13.82	14.22	722	702		
(AC CMS X EL 31) X(133 X201 Rf)	5,510	5,967	20.29	21.49	13.52	13.92	720	682		
(AC CMS X E1 31) X(CT9 X 201Rf)	5,823	5,438	21.18	20.33	13.70	13.39	738	738		
(AC CMS X NB-1) X(CT9 X 201 Rf)	4,963	6,425	18.04	22.83	13.72	14.07	764	676		
(AC CMS X NB-1) X(CT9 X 129 Rf)	5,296	6,353	19.16	22.62	13.80	14.03	746	679		
(AC CMS X NB-1) X(133 X 201 Rf)	4,650	6,077	17.15	21.82	13.54	13.90	747	691		
(AC CMS X NB-1) X(133 X 129 Rf)	4,982	6,247	17.95	22.54	13.84	13.84	749	638		
(Ov CMS X EL 31) X(CT9 X 201 Rf)	5,677	5,790	20.76	21.41	13.65	13.52	728	781		
(Ov CMS X EL 31) X(CT9 X 129 Rf)	5,677	6,591	21.88	23.47	13.72	14.04	710	744		
(Ov CMS X EL 31) X(133 X201 Rf)	5,364	5,426	19.86	19.69	13.46	13.74	711	691		
(Ov CMS X EL 31) X(133 X129 Rf)	5,696	6,591	20.66	23.70	13.76	13.89	713	717		
	$r = -.0027$		$r = -.0072$		$r = .3121$		$r = .4527$			

Table 5 . Reciprocal single-cross variety test, Farmington, Utah, 1970. (18 entries, 6 reps)

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets			Index	Amino N	Na	K	
1	NB-1 X 128	6,876	21.57		15.94	332	142	161	1,322	49
2	128 X NB-1	8,374	26.38		15.91	335	164	162	1,249	63
	Mean	7,625	23.98		15.92	334	153	162	1,786	56
3	CT9 X EL 32	9,769	31.96		15.29	429	148	320	1,582	64
4	EL 32 X CT9	10,690	35.33		15.13	405	154	290	1,422	74
	Mean	10,230	33.64		15.21	417	151	305	1,502	69
5	CT9 X EL 31	7,657	24.37		15.74	444	190	251	1,684	45
6	EL 31 X CT9	9,126	28.38		16.08	345	122	183	1,478	61
	Mean	8,392	26.38		15.91	394	156	217	1,581	53
9	EL 31 X 133	7,691	23.91		16.09	423	255	302	1,283	51
10	133 X EL 31	5,114	15.98		15.96	420	224	306	1,353	28
	Mean	6,402	19.94		16.02	422	240	304	1,318	40
11	CT9 X 133	8,967	29.11		15.38	440	187	310	1,527	50
12	133 X CT9	8,833	28.74		15.38	406	158	267	1,484	57
	Mean	8,900	28.92		15.38	423	172	288	1,506	54
13	NB-1 X 133	9,567	30.47		15.81	397	188	292	1,347	57
14	133 X NB-1	10,523	34.23		15.38	409	219	309	1,208	68
	Mean	10,045	32.35		15.60	403	204	300	1,278	62
15	CT9 X 127	7,096	22.83		15.55	337	112	207	1,357	59
16	127 X CT9	8,574	27.66		15.51	352	126	270	1,304	67
	Mean	7,835	25.25		15.53	344	119	238	1,330	63

Table 5 . continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K	
17	UI check	11,126	35.08	15.88	405	198	293	1,364	68
18	US 22/3 check	8,969	28.15	15.95	441	225	283	1,514	69
	Mean	10,048	31.62	15.92	423	212	288	1,439	68
Means:									
	All reciprocal crosses	8,490	27.21	15.65	391	170	259	1,400	57
	S.E. of Mean	356	1.20	0.18	23	21	23	59	2
	L.S.D. (5% point)	1,006	3.39	0.51	65	59	65	167	6
	C.V. %	10.41	10.99	2.73	14.82	29.05	20.56	10.36	11.98
	Calculated F	31.11**	29.73**	2.91**	2.75**	4.00**	6.49**	4.45**	26.52**

** Significant at 1% level

Table 6 . Transplant vs seeding variety trial, Logan, Utah, 1970. (6 entries, 5 reps)

Code	Description	Index				Amino N					
		Seed	Trans	#1	Trans #2	Mean	Seed	Trans	#1	Trans #2	Mean
401	(CT9 X 133) X (0v X 129 Rf)	572	571		564	569	332	346	337	338	
402	(133 X 35.0v) X (")	628	614		596	613	417	422	426	422	
403	(133 X 0461 S) X (")	583	600		491	558	407	422	339	390	
404	(133 X 0461 S) X (A7113 X 129 Rf)	628	648		682	653	442	439	485	455	
405	(U1 #7) X (0v X 129)	564	565		519	549	345	327	335	336	
406	(133 X CT5) X (0v X 129)	561	667		573	600	334	401	348	361	
Mean all varieties											
		589	611		571	590	380	393	378	383	
L.S.D. (5% point):											
Seed and transplants		NS				48	NS		37		
Varieties											
K											
401	(CT9 X 133) X (0v X 129 Rf)	235	233		230	233	1,585	1,608	1,608	1,600	
402	(133 X 35.0v) X (")	241	216		214	223	1,537	1,589	1,524	1,550	
403	(133 X 0461 S) X (")	239	248		197	228	1,439	1,399	1,190	1,343	
404	(133 X 0461 S) X (A7113 X 129 Rf)	310	290		313	304	1,406	1,496	1,520	1,474	
405	(U1 #7) X (0v X 129)	238	238		219	232	1,565	1,590	1,369	1,508	
406	(133 X CT5) X (0v X 129)	245	252		238	245	1,529	1,657	1,558	1,581	
Mean all varieties											
		251	246		235	244	1,510	1,557	1,462	1,509	
L.S.D. (5% point):											
Seed and transplants		NS				23	99		122		
Varieties											

Table 7 . Transplant vs seeding variety trial, Logan, Utah, 1970. (6 entries, 5 reps)

Code	Description	Gross Sugar			Mean	Tons/acre			
		Seed	Trans #1	Trans #2		Seed	Trans #1	Trans #2	Mean
401	(CT9 X 133) X (0v X 129 Rf)	5,494	6,466	6,100	6,020	19.35	22.26	20.97	20.86
402	(133 X 35.0v) X(")	5,447	5,695	6,412	5,851	19.30	19.30	21.65	20.08
403	(133 X 0461 S) X(")	5,733	4,417	5,238	5,129	19.55	15.10	18.18	17.61
404	(133 X 0461 S) X (A7113 X 129 Rf)	5,926	4,945	5,799	5,557	20.60	17.29	20.10	19.33
405	(U1 #7) X (0v X 129)	6,375	5,234	6,445	6,018	21.92	18.31	22.27	20.83
406	(133 X CT5) X (0v X 129)	6,497	4,148	6,410	5,685	22.70	14.67	22.39	19.92
Mean all varieties									
L.S.D. 5% point:									
Seed and transplants									
Varieties									
		5,912	5,151	5,967	5,710	20.57	17.82	20.93	19.77
		733			502	2.20			1.55
Percent Sucrose									
401	(CT9 X 133) X (0v X 129 Rf)	14.17	14.52	14.54	14.41	66	60	59	62
402	(133 X 35.0v) X(")	14.11	14.64	14.80	14.52	65	57	59	60
403	(133 X 0461 S) X(")	14.62	14.39	14.35	14.45	74	55	57	62
404	(133 X 0461 S) X (A7113 X 129 Rf)	14.37	14.22	14.37	14.32	71	54	58	61
405	(U1 #7) X (0v X 129)	14.54	14.31	14.50	14.45	74	57	60	64
406	(133 X CT5) X (0v X 129)	14.32	13.82	14.35	14.16	75	48	58	60
Mean all varieties									
L.S.D. 5% point:									
Seed and transplants									
Varieties									
		14.36	14.32	14.49	14.39	71	55	59	62
		NS			NS	6			4

Table 8 . Transplant vs seeding variety trial, Logan, Utah, 1970. (6 entries, 5 reps)

Variance Table

Source of Variation	DF	Gross Sugar		Tons/acre		Sugar		Index	
		Mean	F	Mean	F	Mean	F	Mean	F
		Square		Square		Square		Square	
Replications	4	14.52 X 10 ⁵		18.11		.1263		41.87 X 10 ³	
Treatment	2	72.27 X 10 ⁵	7.45**	86.32	9.53**	.2335	NS	12.01 X 10 ³	NS
Varieties	5	17.21 X 10 ⁵	NS	21.82	2.41*	.2406	NS	23.06 X 10 ³	2.62*
Treatments X Varieties	10	20.12 X 10 ⁴	2.07*	20.53	2.27*	.2595	NS	61.36 X 10 ²	NS
Error	68	97.02 X 10 ⁵		9.05		.4203		87.96 X 10 ²	
Total	89	12.92 X 10 ⁵		13.20		.3747		10.86 X 10 ³	

	Amino N		Na		K		Beet Count	
	Mean	F	Mean	F	Mean	F	Mean	F
	Square		Square		Square		Square	
Replications	38.56 X 10 ³		75.01 X 10 ²		49.84 X 10 ³		79.43	
Treatment	18.87 X 10 ²	NS	20.45 X 10 ²	NS	67.65 X 10 ³	NS	20.82 X 10 ²	29.15
Varieties	34.42 X 10 ³	6.76	13.87 X 10 ²	6.80**	13.27 X 10 ⁴	4.80**	26.53	NS
Treatments X Varieties	36.20 X 10 ²	NS	88.57 X 10 ²	NS	28.49 X 10 ³	NS	82.96	NS
Error	50.88 X 10 ²		20.41 X 10 ²		27.65 X 10 ³		73.95	
Total	80.03 X 10 ²		28.21 X 10 ²		35.54 X 10 ³		11.77 X 10	

Table 9. Hybrid variety trial, 3-way vs 4-way hybrids, combined locations, Logan and Farmington, Utah, 1970. (28 entries, 6 reps)

Variance Table											
Source of Variation	DF	Gross Sugar		Tons/Acre		Sucrose		Index			
		Mean	Square	F	Mean	Square	F	Mean	Square		
Locations	1	41.73X	10 ⁷	551.05**	29.34X	10 ²	360.15**	74.69	310.54**	51.79X	10 ⁴
Rep and locations	10	32.05X	10 ⁵		41.63		5.11**	1.53		79.58X	10 ³
Females	2	16.55X	10 ⁶	21.85**	28.10X	10	34.54**	4.48	18.64**	59.13X	10 ³
Males	4	58.03X	10 ⁵	7.66**	68.55		8.41**	.23	NS	26.64X	10 ³
Females X males	8	12.55X	10 ⁵	NS	17.87		2.19*	.57	2.36*	15.32X	10 ³
Loc X females	2	15.95X	10 ⁵	NS	21.96		NS	.63	NS	20.87X	10 ³
Loc X males	4	16.58X	10 ⁴	NS	1.31		NS	.43	NS	10.79X	10 ²
Loc X males X females	8	27.41X	10 ⁵	3.62**	37.22		4.57**	.37	NS	39.51X	10 ²
Error	140	75.74X	10 ⁵		8.15			.24		59.23X	10 ²
Total	179	36.18X	10 ⁵		32.50			.81		14.56X	10 ³

Source of Variation	DF	Amino N		F	Na	K	F		Beet Count	
		Mean	Square				Mean	Square	Mean	Square
Locations	1	50.40X	10 ³	115.13**	86.64X	10 ³	36.97**	64.94X10 ³	44.81	X 10
Rep and locations	10	62.65X	10 ²		28.89X	10 ³		17.09X10 ⁴	16.30	X 10
Females	2	45.47X	10 ³	NS	58.04X	10 ³	24.77**	13.93X10 ⁴	62.18	X 10 ²
Males	4	16.47X	10 ²	3.76**	15.11X	10 ²	6.45**	26.84X10 ³	82.89	X 10 ²
Females X males	8	72.64X	10 ²	NS	90.34X	10 ²	3.86**	85.31X10 ³	28.90	X 10
Loc X females	2	12.19X	10 ³	NS	59.13X	10 ²	NS	38.49X10 ³	51.36	
Loc X males	4	15.27X	10 ²	3.49**	36.61X	10 ²	NS	24.82X10 ³	86.75	X 10
Loc X males X females	8	19.39X	10 ²	NS	53.40X	10 ²	2.28*	40.28X10 ³	29.75	X 10
Error	140	43.78X	10 ²		23.43X	10 ²		29.25X10 ³	51.64	
Total	179	11.05X	10 ³		57.07X	10 ²		46.95X10 ³	29.03X	10

* Significant at 5% level

** Significant at 1% level

Table 10 . Hybrid variety trial, 3-way vs 4-way hybrids, Logan, Utah, 1970. (28 entries, 6 reps)

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons	Beets		Index	Amino N	Na	K	
1	(UI 11863 X CT7) X 129 Rf	5,864	20.07		14.64	520	338	161	1,459	76
2	(UI 11863 X CT7) X (CT9 X 129 Rf)	6,014	20.59		14.60	510	315	187	1,461	81
3	(UI 11863 X CT7) X (133 X 129 Rf)	6,529	22.18		14.68	459	306	182	1,216	76
4	(UI 11863 X CT7) X (EL 32 X 129 Rf)	3,805	13.05		14.59	584	357	207	1,681	24
5	(UI 11863 X CT7) X (A7113 X 129 Rf)	6,785	23.44		14.46	578	383	225	1,500	79
6	(UI 11863 X CT7) X (Ov X 129 Rf)	6,202	21.26		14.63	454	298	179	1,222	75
7	UI #7 X 129 Rf	6,359	22.85		13.90	617	393	241	1,516	81
8	UI #7 X (CT9 X 129 Rf)	6,347	22.65		14.01	587	320	241	1,669	75
9	UI #7 X (133 X 129 Rf)	5,968	21.74		13.75	555	341	266	1,298	85
10	UI #7 X (EL 32 X 129 Rf)	2,231	8.39		13.29	644	343	266	1,664	21
11	UI #7 X (A7113 X 129 Rf)	6,924	24.34		14.22	581	369	245	1,486	84
12	UI #7 X (Ov X 129 Rf)	6,291	22.57		13.93	582	333	235	1,562	80
13	(133 X 712) X 129 Rf	6,663	23.14		14.43	571	357	187	1,608	77
14	(133 X 712) X (CT9 X 129 Rf)	6,551	23.19		14.08	477	251	221	1,373	79
15	(133 X 712) X (EL 32 X 129 Rf)	6,228	21.69		14.36	588	327	238	1,721	57
16	(133 X 712) X (A7113 X 129 Rf)	6,433	22.75		14.13	638	416	251	1,579	83
17	(133 X 712) X (Ov X 129 Rf)	5,964	21.69		13.73	555	283	235	1,574	75
18	(Ov X 712) X 129 Rf	6,272	22.67		13.82	593	314	254	1,660	77
19	(Ov X 712) X (CT9 X 129 Rf)	6,916	24.99		13.83	567	296	232	1,616	75
20	(Ov X 712) X (EL 32 X 129 Rf)	6,221	22.34		13.93	498	231	236	1,520	80
21	(Ov X 712) X (A7113 X 129 Rf)	6,719	25.30		13.28	753	427	314	1,848	75
22	(133 X F.C. 601) X 129 Rf	5,901	20.77		14.18	494	283	215	1,371	73
23	(133 X F.C. 601) X (EL 32 X 129 Rf)	4,957	17.47		14.14	487	277	194	1,374	73
24	(133 X F.C. 601) X (A7113 X 129 Rf)	6,499	22.72		14.29	601	390	220	1,562	84
25	(133 X F.C. 601) X (Ov X 129 Rf)	6,226	21.43		14.53	505	289	217	1,471	76

Table 10. continued

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons	Beets		Index	Amino N	Na	K	
26	US 22/2 check	6,077	21.13		14.39	618	377	237	1,718	72
27	UI Hybrid #7	7,389	25.89		14.26	606	405	252	1,487	76
28	Amalgamated commercial check	6,489	22.39		14.48	519	319	181	1,474	83
Mean of all varieties										
S.E. of Mean		6,101	21.52		14.16	562	333	226	1,524	73
L.S.D. (5% point)		300	0.93		0.19	28	24	17	75	3
C.V. %		831	2.58		0.53	78	67	47	208	8
Calculated F		12.06	10.63		3.28	12.48	17.36	18.48	12.00	11.39
		11.05**	14.31**		4.05**	5.23**	4.40**	3.76**	4.06**	20.29**

** Significant at 1% level

Table 11 . Hybrid variety trial, 3-way vs 4-way hybrids,
6 reps)

Farmington, Utah, 1970 (28 entries,

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K	
1	(UI 11863 X CT7) X 129 Rf	8,367	26.91	15.57	391	189	192	1,387	70
2	(UI 11863 X CT7) X (CT9 X 129 Rf)	8,526	26.61	16.06	402	206	179	1,472	66
3	(UI 11863 X CT7) X (133 X 129 Rf)	8,364	26.38	15.87	408	234	229	1,321	67
4	(UI 11863 X CT7) X (EL 32 X 129 Rf)	8,296	26.20	15.83	444	243	203	1,556	50
5	(UI 11863 X CT7) X (A7113 X 129 Rf)	9,356	30.98	15.09	510	235	362	1,617	68
6	(UI 11863 X CT7) X (0v X 129 Rf)	8,090	25.22	16.06	366	197	179	1,305	66
7	UI #7 X 129 Rf	9,521	30.72	15.48	404	197	264	1,344	70
8	UI #7 X (CT9 X 129 Rf)	10,183	33.48	15.21	482	258	287	1,471	74
9	UI #7 X (133 X 129 Rf)	9,009	29.67	15.18	465	296	331	1,173	71
10	UI #7 X (EL 32 X 129 Rf)	8,272	26.61	15.57	451	203	269	1,605	44
11	UI #7 X (A7113 X 129 Rf)	9,919	32.14	15.43	449	230	271	1,455	73
12	UI #7 X (0v X 129 Rf)	9,438	30.91	15.28	500	268	305	1,548	72
13	(133 X 712) X 129 Rf	9,878	31.86	15.57	466	250	286	1,475	75
14	(133 X 712) X (CT9 X 129 Rf)	10,031	32.30	15.53	454	212	277	1,555	74
15	(133 X 712) X (EL 32 X 129 Rf)	9,267	30.29	15.31	525	259	297	1,762	50
16	(133 X 712) X (A7113 X 129 Rf)	9,672	32.17	15.11	506	277	303	1,483	74
17	(133 X 712) X (0v X 129 Rf)	10,057	33.17	15.24	527	271	304	1,467	73
18	(0v X 712) X 129 Rf	9,848	34.30	14.32	557	256	311	1,700	71
19	(0v X 712) X (CT9 X 129 Rf)	10,291	34.74	14.80	553	293	333	1,631	66
20	(0v X 712) X (EL 32 X 129 Rf)	8,470	28.51	14.80	525	210	284	1,818	45
21	(0v X 712) X (A7113 X 129 Rf)	10,113	34.92	14.51	634	317	385	1,847	69
22	(133 X F.C. 601) X 129 Rf	8,416	27.66	15.23	423	192	229	1,490	59
23	(133 X F.C. 601) X (EL 32 X 129 Rf)	7,547	24.99	15.19	444	196	240	1,575	42
24	(133 X F.C. 601) X (A7113 X 129 Rf)	9,540	30.75	15.52	435	249	255	1,349	75
25	(133 X F.C. 601) X (0v X 129 Rf)	9,360	30.67	15.29	420	186	282	1,413	75

Table 11. continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
					Index	Amino N	Na	K	
26	US 22/2 check	8,827	28.10	15.72	427	198	245	1,538	65
27	UI #7 check	10,812	35.03	15.43	445	247	312	1,282	70
28	Amalgamated commercial check	9,975	32.07	15.55	342	168	188	1,192	72
Mean of all varieties									
S. E. of mean		9,266	30.26	15.35	462	233	271	1,494	66
L.S.D. (5% point)		403	1.32	0.22	34	29	25	70	3
C.V. %		1,117	3.66	0.61	94	80	69	194	8
Calculated F		10.67	10.66	3.59	17.79	30.61	22.39	11.54	12.35
		4.15**	5.46**	3.30**	3.62**	1.73*	4.63**	5.82**	9.16**

* Significant at 5% level

** Significant at 1% level

Table 12. Hybrid variety trial, 3-way vs 4-way hybrids, combined locations, Logan and Farmington, Utah, 1970. (15 entries, 6 reps)

Description	Gross Sugar			Tons/Acre			Percent Sugar			Index		
	Loc 1	Loc 2	Comb.	Loc 1	Loc 2	Comb.	Loc 1	Loc 2	Comb.	Loc 1	Loc 2	Comb.
(U1 11863XCT7) X 129 Rf	5,864	8,367	7,116	20.07	26.92	23.49	14.64	15.57	15.10	520	391	455
do X (CT9X 129Rf)	6,014	8,526	7,270	20.59	26.61	23.60	14.60	16.06	15.33	510	402	456
do X (EL 32X 129Rf)	3,805	8,296	6,050	13.05	26.20	19.62	14.59	15.83	15.21	584	444	514
do X (A7113X 129Rf)	6,785	9,356	8,071	23.44	30.98	27.21	14.46	15.09	14.78	578	510	544
do X (Ov X 129Rf)	6,202	8,090	7,146	21.26	25.22	23.24	14.63	16.06	15.34	454	366	410
Mean of females	5,734	8,527	7,130	19.68	27.18	23.43	14.58	15.72	15.15	529	422	476
U1 #7 X 129 Rf	6,359	9,521	7,940	22.85	30.72	26.79	13.90	15.48	14.69	617	404	511
do X (CT9 X 129 Rf)	6,347	10,183	8,265	22.65	33.48	28.06	14.01	15.21	14.61	587	482	535
do X (EL 32 X 129 Rf)	6,761	8,272	7,517	25.16	26.61	17.50	13.29	15.57	14.43	644	451	547
do X (A7113 X 129 Rf)	6,924	9,919	8,422	24.34	32.14	28.24	14.22	15.43	14.82	581	449	515
do X (Ov X 129 Rf)	6,291	9,438	7,865	22.57	30.91	26.74	13.93	15.28	14.60	582	500	541
Mean of females	6,536	9,467	8,001	23.51	30.77	27.14	13.87	15.39	14.63	602	457	530
(133 X 712) X 129 Rf	6,663	9,878	8,271	23.14	31.86	27.50	14.43	15.57	15.00	571	466	519
do X (CT9 X 129 Rf)	6,551	10,031	8,291	23.19	32.30	27.74	14.08	15.53	14.81	477	454	466
do X (EL 32 X 129Rf)	6,228	9,267	7,748	21.69	30.29	25.99	14.36	15.31	14.83	588	525	556
do X (A7113 X 129 Rf)	6,433	9,672	8,053	22.75	32.17	27.46	14.13	15.11	14.62	638	506	572
do X (Ov X 129 Rf)	5,964	10,057	8,010	21.69	33.17	27.43	13.73	15.24	14.49	555	527	541
Mean of females	6,368	9,781	8,074	22.49	31.96	27.22	14.15	15.35	14.75	566	496	531
Mean of all varieties	6,213	9,258	7,735	20.78	29.97	25.93	14.20	15.48	14.84	566	484	512
L.S.D. between varieties			1,003			3.31			0.57			89
do females			316			1.05			0.18			28
do males			410			1.36			NS			36
Mean of males:												
129 Rf			7,775			25.92			14.93			495
CT9 X 129 Rf			7,942			26.47			14.91			485
EL 32 X 129 Rf			7,105			23.83			14.82			539
A7113 X 129 Rf			8,181			27.64			14.74			544
Ov X 129 Rf			7,674			25.80			14.81			497

Table 12. Hybrid variety trial, 3-way vs 4-way hybrids, combined locations, Logan and Farmington, Utah, 1970. (15 entries, 6 reps) continued

Description	Amino N			Na			K			Beet Count		
	Loc 1		Loc 2	Loc 1		Loc 2	Loc 1		Loc 2	Loc 1		Comb
	Loc 1	Loc 2	Comb	Loc 1	Loc 2	Comb	Loc 1	Loc 2	Comb	Loc 1	Loc 2	Comb
(U1 11863CT7) X 129 Rf	338	189	263	161	192	177	1,459	1,387	1,422	76	70	73
do X (CT9X129Rf)	315	206	260	187	179	183	1,461	1,472	1,466	81	66	73
do X(EL32X 129Rf)	357	243	300	207	203	205	1,681	1,556	1,618	24	50	37
do X(A7113X 129Rf)	383	235	309	225	362	293	1,500	1,617	1,558	79	68	73
do X(Ov X 129Rf)	298	197	247	179	179	179	1,222	1,305	1,263	75	66	71
Mean of females	338	214	276	192	223	207	1,464	1,467	1,466	67	64	65
U1 #7 X 129 Rf	393	198	295	241	264	253	1,516	1,344	1,430	81	70	76
do X (CT9 X 129 Rf)	320	258	289	241	287	264	1,669	1,471	1,570	75	74	74
do X (EL 32 X 129 Rf)	343	203	273	266	269	268	1,664	1,605	1,634	21	44	33
do X (A7113 X 129 Rf)	369	230	299	245	271	258	1,486	1,455	1,470	84	73	78
do X(Ov X 129 Rf)	333	268	301	235	305	270	1,562	1,548	1,555	80	72	76
Mean of females	352	231	291	246	279	263	1,579	1,485	1,532	68	67	67
(133 X 712) X 129 Rf	357	250	304	187	286	236	1,608	1,475	1,541	77	75	76
do X(CT9 X 129 Rf)	251	212	232	221	277	249	1,373	1,555	1,464	79	74	76
do X(EL 32 X 129 Rf)	327	259	293	238	297	267	1,721	1,762	1,742	57	50	54
do X(A7113 X 129 Rf)	416	277	347	251	303	277	1,579	1,483	1,531	83	74	78
do X(Ov X 129 Rf)	283	271	277	235	304	269	1,574	1,467	1,520	75	73	74
Mean of females	327	254	290	226	293	260	1,571	1,548	1,560	74	69	72
Mean of all varieties	339	233	286	221	265	243	1,538	1,500	1,519	70	66	68
L.S.D. between varieties			76			56			197			8
do females			24			18			62			3
do males			31			23			81			4
Mean of males:												
129 Rf			287			222			1,464			75
CT9 X 129 Rf			260			232			1,500			74
EL 32 X 129 Rf			288			247			1,665			48
A7113 X 129 Rf			318			276			1,520			76
Ov X 129 Rf			275			239			1,446			73

Table 13. New single cross variety trial, Logan, Utah, 1970. (40 entries, 5 reps)

Code	Description	Acre Yield			Percent Sugar	PPM			Beet Count
		Gross Sugar	Tons Beets			Index	Amino N	Na K	
8	EL 32 X Ov.1	8,001	27.05		14.80	666	454	268	1,749
27	Ov. X 0198 S (323)	7,923	28.01		14.13	869	580	201	1,778
31	Ov. X CT9	7,897	24.64		16.20	550	357	225	1,684
28	133 X 0198 S (323)	7,825	26.68		14.68	752	606	221	1,677
16	A7113 X CT8	7,380	24.95		14.73	617	388	268	1,687
6	Ov. 2 X 129	7,335	24.73		14.83	402	215	204	1,239
7	CT9 X Ov.1	7,257	25.01		14.50	598	393	219	1,591
26	129 X A7134	7,058	24.98		14.13	605	358	224	1,672
18	EL 32 X CT8	7,033	25.94		13.54	757	460	376	1,721
11	NB-1 X 5.9 S	7,005	23.75		14.76	644	417	187	1,869
20	(S33 X 9A) X CT8	6,989	24.12		14.50	572	353	218	1,598
17	A7112 X CT8	6,915	24.49		14.11	610	384	230	1,576
33	CT9 X A7135	6,869	23.50		14.62	609	345	252	1,827
25	S33.9A X A7134	6,839	24.09		14.21	629	389	221	1,692
37	UI #7 check	6,824	22.45		15.19	516	403	206	1,227
22	CT9 X A7134	6,823	25.54		13.37	659	340	265	1,795
36	Ov X L-19	6,781	22.08		15.36	632	440	248	1,767
9	A7112 X 5.9 S	6,719	22.60		14.88	606	360	207	1,871
21	Ov.1 X CT8	6,681	23.75		14.04	630	397	252	1,595
23	(90.68 X 129AA) X A7134	6,662	23.35		14.26	579	324	254	1,596
5	A7112 X 129	6,651	22.70		14.65	599	439	192	1,482
29	NB-1 X 129 Rf	6,606	22.70		14.57	475	296	172	1,349
14	(S33 X 9A) X 30.002	6,517	22.11		14.73	679	557	150	1,560
32	129 X A7135	6,504	22.51		14.43	608	399	219	1,604
35	129 X L-19	6,496	20.50		15.85	521	367	184	1,578

Table 13. continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
					Index	Amino N	Na	K	
13	A7113 X 30.002	6,439	21.68	14.85	691	535	217	1,656	64
15	CT9 X CT8	6,412	24.21	13.18	647	363	257	1,619	67
1	CT9 X CT8	6,401	22.14	14.42	668	462	187	1,733	77
30	133 X LSR-CTR Sel	6,368	22.48	14.17	634	414	183	1,679	79
12	CT9 X 30.002	6,330	22.79	13.88	724	404	244	2,049	59
4	A7112 X CT8	6,314	20.75	15.21	437	291	154	1,279	72
3	(90.68 X 129AA) X CT8	6,207	20.66	15.01	567	402	170	1,553	75
10	0v.2 X 5.9 S	6,145	20.94	14.69	455	245	151	1,490	76
34	133 X A7135	6,097	21.68	14.08	713	557	238	1,459	74
19	129 X A7134	5,972	22.02	13.58	671	395	308	1,628	69
40	Logan high-yield check	5,941	20.88	14.23	451	243	233	1,266	63
24	NB-1 X A7134	5,893	21.37	13.79	665	387	284	1,720	46
38	Amalgamated commercial check	5,764	19.43	14.81	412	249	168	1,204	68
39	US 22/3 check	5,649	19.05	14.88	557	336	244	1,619	72
2	A7113 X CT8	5,434	19.67	13.77	564	404	140	1,356	78
Mean of all varieties									
S.E. of Mean		6,674	23.05	14.49	606	393	221	1,602	72
L.S.D. (5% point)		347	0.95	0.47	38	31	20	103	3
C.V. %		962	2.63	1.30	105	86	55	285	8
Calculated F		11.62	9.17	7.18	14.07	17.68	19.94	14.44	10.72
		3.11**	4.90**	1.78**	6.56**	8.22**	5.57**	3.41**	4.10**

** Significant at 1% level

Table 14. New pollen-restorer hybrid variety trial, Farmington, Utah, 1970. (38 entries, 5 reps)

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons	Beets		Index	Amino N	Na	K	
31	(133 X 129) X A7134	10,850	35.08		15.55	391	155	283	1,423	80
35	(133 X 0198 S)(323)(high-yield check)	10,728	31.78		16.93	462	318	242	1,505	80
17	(EL 32 X 133) X (A7113 X 129 Rf)	10,597	32.80		16.16	441	204	330	1,566	81
27	(EL 32 X CT9) X (0v X 129 Rf)	10,002	32.21		15.51	365	166	236	1,258	76
16	(0v X 9540) X (A7113 X 129 Rf)	9,814	31.44		15.58	410	151	294	1,542	80
36	UI #7 check	9,786	30.54		16.02	278	106	209	1,067	75
11	(133 X 0461 S) X (A7113 X 129 Rf)	9,713	29.18		16.60	372	178	256	1,393	71
34	(0v X 0198 S)(323)(high-yield check)	9,693	29.98		16.22	495	279	229	1,765	73
4	(A7113 X 133) X (CT9 X 129 Rf)	9,662	30.82		15.68	395	159	288	1,439	78
7	(0v X CT5B) X (133 X 129 Rf)	9,605	30.17		15.91	346	141	249	1,284	75
14	(0v.1 X CT5B) X (A7113 X 129 Rf)	9,552	30.36		15.80	430	185	289	1,557	83
25	(A7112 X CT9) X (0v X 129 Rf)	9,530	29.98		15.89	454	233	282	1,548	80
33	0v X L-19 (high-sugar check)	9,521	28.44		16.75	426	219	274	1,595	68
28	(CT9 X 122) X (0v X 129 Rf)	9,510	30.20		15.78	433	205	298	1,493	74
13	(F.C. 601 X CT5) X (A7113 X 129 Rf)	9,482	29.74		15.91	370	150	242	1,415	80
1	(133 X 0461 S) X (CT9 X 129 Rf)	9,457	28.93		16.35	382	207	227	1,345	75
8	(A7112 X CT9) X (133 X 129 Rf)	9,331	29.06		16.07	326	133	205	1,275	74
29	(A7113 X 133) X (0v X 129 Rf)	9,322	28.87		16.13	372	164	268	1,373	83
24	(F.C. 601 X CT5) X (0v X 129 Rf)	9,261	28.84		16.07	366	172	231	1,342	71
30	(133 X 0464) X (0v X 129 Rf)	9,253	28.87		16.00	473	288	248	1,518	77
15	(0v X 133) X (A7113 X 129 Rf)	9,242	29.95		15.45	410	144	320	1,513	80
2	(0v X 22.005) X (CT9 X 129 Rf)	9,230	29.77		15.49	452	209	272	1,578	72
18	(EL 32 X CT9) X (A7113 X 129 Rf)	9,223	28.87		15.98	393	172	254	1,461	78
26	(EL 32 X 133) X (0v X 129 Rf)	9,138	29.34		15.56	462	231	327	1,493	77
20	(0v X 0461 S) X (A7113 X 129 Rf)	9,049	28.26		16.00	440	231	272	1,511	72

Table 14. continued

Code	Description	Acre Yield		Percent Sugar	PPM			Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K
37	Amalgamated commercial check							
6	(F.C. 601 X CT5) X (133 X 129 Rf)	9,035	27.67	16.33	291	109	157	1,247
23	(0v X 22.005) X (0v X 129 Rf)	8,997	28.07	16.03	417	229	270	1,356
3	(133 X 22.005) X (CT9 X 129 Rf)	8,937	28.47	15.70	441	189	290	1,592
12	(133 X 22.005) X (A7113 X 129 Rf)	8,770	27.02	16.26	349	150	207	1,378
		8,551	26.55	16.11	361	154	247	1,363
5	(0v X 22.005) X (133 X 129 Rf)	8,449	26.77	15.78	424	224	272	1,404
22	(133 X 0461 S) X (A7113 X 129 Rf)	8,411	25.91	16.30	427	246	270	1,406
32	129 X L-19 (high-sugar check)	8,347	23.22	17.94	350	184	149	1,571
21	(CT9 X 133) X (A7113 X 129 Rf)	8,202	25.91	15.80	415	189	250	1,516
9	(F.C. 601 X CT5) X (EL 32 X 129 Rf)	7,882	25.04	15.72	361	157	178	1,389
38	US 22/3 check	7,588	24.30	15.65	375	137	284	1,399
19	(CT9 X A.C.) X (A7113 X 129 Rf)	7,547	27.30	14.05	368	122	222	1,284
10	(0v.1 X CT5B) X (EL 32 X 129 Rf)	7,242	23.75	15.25	420	138	282	1,616
	Mean of all varieties	9,171	28.77	15.96	399	185	255	1,442
	S.E. of mean	465	1.38	0.32	25	26	22	60
	L.S.D. (5% point)	1,289	3.82	0.89	69	72	61	166
	C.V. percent	11.33	10.76	4.55	13.86	31.48	19.07	9.26
	Calculated F	3.06**	3.20**	3.15**	3.89**	3.52**	3.68**	4.86**

** Significant at 1% level

Table 15 . Single-cross variety trial, Logan, Utah, 1970. (38 entries, 6 reps)

Code	Description	Acre Yield		Percent Sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets			Amino N	Na	K	
34	128 CMS X (133 X m'm')	7,020	22.49	15.61	449	286	176	1,412	70
27	0v CMS X 29.005	6,792	24.63	13.82	776	476	288	1,979	70
20	129 CMS X 0461 S (246)	6,785	21.49	15.76	554	539	183	1,090	68
33	SLC 129 CMS X (133 X m'm')	6,568	21.23	15.47	555	338	210	1,789	65
26	0v CMS X A7135	6,416	22.57	14.23	688	485	248	1,610	68
22	0v CMS X L-13	6,326	22.24	14.24	691	444	259	1,781	62
14	0v CMS X EL 31	6,317	21.10	14.96	618	486	195	1,478	66
9	NB-1 CMS X EL 31	6,308	21.62	14.54	634	436	267	1,560	57
12	EL 32 X 133	6,214	21.13	14.71	637	496	225	1,448	69
35	0v CMS X (133 X m'm')	6,177	21.77	14.18	745	464	273	1,951	68
15	128 CMS X A7111	6,175	20.92	14.73	535	310	241	1,572	63
5	0v CMS X 29.002	6,174	21.51	14.35	576	367	211	1,533	70
18	0v CMS X 28.19	6,150	20.66	14.89	553	369	221	1,507	67
17	0v CMS X A7111	6,078	21.49	14.13	692	429	261	1,798	61
4	EL 32 CMS X 129 Rf	6,077	20.82	14.58	589	366	230	1,651	59
31	0v CMS X 0461 S (282)	6,021	20.10	15.02	546	316	213	1,715	68
37	Amalgamated check	6,008	20.69	14.43	527	307	187	1,552	69
7	0v CMS X SLC 133	5,974	20.59	14.53	721	550	233	1,648	59
36	0v CMS X (127 X 0v 3)	5,958	19.74	15.08	572	455	169	1,373	68
21	A7113 CMS X NB-1	5,884	19.27	15.29	616	426	249	1,704	46
8	A7113 CMS X SLC 133	5,875	19.20	15.30	589	445	223	1,482	56
25	128 CMS X A7111	5,802	19.69	14.73	551	357	223	1,490	68
1	0v CMS X SLC 129 Rf	5,681	18.81	15.12	530	352	182	1,544	61
24	129 CMS X A7111	5,667	19.23	14.76	665	496	227	1,614	68
6	129 CMS X 133	5,666	18.76	15.09	556	418	201	1,401	51

Table 15 . continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K	
3	A7113 CMS X 129 Rf	5,645	18.45	15.30	532	371	213	1,473	63
10	129 CMS X EL 31	5,622	18.81	14.98	612	483	219	1,422	50
11	A7112 CMS X EL 31	5,467	18.19	15.00	585	422	199	1,534	55
19	133 CMS X LSR-CTR sel	5,465	19.53	13.96	706	478	315	1,569	56
29	129 CMS X (122 X 00.5)	5,110	17.27	14.83	550	339	204	1,612	45
23	128 CMS X L-13	5,002	15.77	15.88	450	295	155	1,459	44
30	129 CMS X 0461 S (282)	4,923	16.81	14.66	466	223	204	1,553	58
38	Amalgamated check	4,777	17.29	13.82	558	343	196	1,438	68
32	128 CMS X 0461 S (282)	4,777	15.85	15.07	477	287	167	1,493	56
2	A7112 CMS X 129 Rf	4,743	15.93	14.87	522	338	200	1,467	56
28	133 CMS X 0198 S	4,485	15.39	14.56	663	456	134	1,841	33
16	SLC 129 CMS X A7111	3,816	12.87	14.82	544	304	168	1,768	25
13	128 CMS X EL 31	3,048	10.40	14.66	674	498	203	1,675	20
Mean of all varieties									
S. E. of Mean		5,710	19.32	14.79	592	401	215	1,579	59
L.S.D. (5% point)		300	0.92	0.21	27	28	12	68	3
C.V. %		831	2.55	0.58	75	78	33	188	8
Calculated F		12.85	11.69	3.44	10.97	16.92	14.07	10.62	13.12
		7.41**	9.35**	5.77**	9.36**	8.64**	9.24**	6.23**	15.02**

** Significant at 1% level.

Table 16 . New 3-way hybrid variety trials, Logan, Utah, 1970. (70 entries, 6 reps)

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K	
24	(S33 X NB-1) X 0198 S	7,663	24.55	15.62	489	153	1,639	82	
23	(EL 31 X 030) X 0198 S	7,439	23.96	15.53	548	194	1,649	79	
64	(129 X 0v.2) X L-19	7,298	22.39	16.31	362	175	1,467	81	
26	(F.C. 601 X CT5) X 0198 S	7,249	24.24	14.95	489	176	1,552	83	
67	(90.68 X m') X L-19	7,150	21.41	16.69	370	183	1,541	75	
66	(EL 31 X 030) X L-19	7,081	21.18	16.72	329	218	1,476	70	
43	(F.C. 601 X CT9) X 0198 S	7,058	24.17	14.59	492	233	1,581	81	
59	(S33 X NB-1) X L-19	7,022	20.92	16.78	325	166	1,484	79	
63	(NB-1 X EL 31) X L-19	7,004	21.28	16.47	395	212	1,480	77	
22	7114 X 0198 S (323)	6,816	22.77	14.93	492	206	1,564	77	
25	(133 X CT5) X 0198 S	6,811	22.47	15.16	531	200	1,482	81	
9	(129 X 0v.1) X A7111	6,715	21.56	15.55	354	239	1,320	65	
57	(S33 X NB-1) X 127.0v3	6,665	21.69	15.36	326	191	1,391	76	
54	(S33 X NB-1) X (133 X m')	6,642	21.64	15.33	353	243	1,724	76	
45	(NB-1 X 0v.3) X 22.005	6,582	22.33	14.74	447	296	1,628	72	
41	(133 X CT5) X 0198 S	6,572	22.42	14.59	498	223	1,602	79	
55	(129 X 0v.2) X (133 X m')	6,476	21.08	15.39	286	209	1,560	78	
61	(133 X CT5) X L-19	6,472	19.81	16.34	349	196	1,389	78	
62	(129 X 0v.1) X L-19	6,468	19.53	16.57	347	173	1,326	76	
65	(129 X 0v.3) X L-19	6,463	19.33	16.72	408	165	1,398	74	
46	(133 X CT5) X 22.005	6,441	21.46	15.03	416	220	1,552	77	
42	7114 X 0198 S	6,436	21.28	15.09	378	181	1,550	72	
38	(S33 X NB-1) X 29.005	6,435	21.80	14.75	455	201	1,735	73	
30	(S33 X NB-1) X 0461 S	6,417	20.48	15.63	515	188	1,267	76	
18	(EL 31 X 030) X 28.19	6,406	19.87	16.12	377	205	1,266	69	

Table 16 . continued

Code	Description	Acre Yield		Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets		Index	Amino N	Na	K	
13	(133 X CT5) X A7111	6,391	20.35	15.70	523	374	236	1,455	62
16	(133 X CT5) X 28.19	6,377	20.41	15.63	498	397	175	1,275	77
68	UI X L-19	6,364	19.22	16.54	458	385	170	1,244	75
52	(129 X Ov.1) X (133 X m')	6,317	20.48	15.43	507	313	229	1,557	71
39	(133 X CT5) X 29.005	6,296	21.13	14.90	614	443	234	1,553	76
37	7114 X A7135	6,294	21.72	14.47	601	389	260	1,563	79
6	(133 X CT5) X 29.002	6,289	20.41	15.40	482	356	161	1,321	85
51	7114 X (133 X m')	6,275	20.90	15.01	510	295	223	1,573	76
40	7114 X 29.005	6,262	21.93	14.28	658	457	255	1,573	71
4	(133 X 9540) X 29.002	6,254	20.82	15.02	497	333	187	1,390	72
10	(129 X Ov.3) X A7111	6,236	20.20	15.43	547	367	226	1,588	56
15	(Ov.1 X 9A) X 28.19	6,229	20.43	15.26	496	326	240	1,385	76
53	(129 X Ov.3) X (133 X m')	6,193	20.12	15.36	613	424	249	1,713	73
49	(129 X Ov.3) X 0461 S	6,159	20.46	15.05	542	367	191	1,525	72
5	(533 X NB-1) X 29.002	6,142	20.25	15.17	438	292	155	1,271	79
35	(129 X Ov.1) X A7135	6,118	20.61	14.84	542	383	200	1,403	75
56	7114 X (127 X Ov.3)	6,108	20.92	14.60	460	310	171	1,196	75
3	(133 X 030) X 29.002	6,068	20.64	14.73	497	335	213	1,290	76
1	(133 X 712) X 129 Rf	6,067	19.77	15.33	471	303	185	1,411	78
60	(133 X 030) X L-19	6,059	18.19	16.64	440	329	217	1,304	70
19	(133 X 030) X L-19	6,047	19.63	15.40	479	335	220	1,302	74
33	(129 X Ov.3) X A7135	5,976	20.10	14.87	586	432	236	1,431	73
29	(129 X Ov.2) X 0461 S	5,930	18.48	16.00	503	465	161	1,113	75
58	(133 X 030) X 127. Ov.3	5,886	19.66	14.97	518	374	204	1,313	69
36	(129 X Ov.2) X A7135	5,875	19.92	14.73	541	375	212	1,391	75

Table 16. continued

Code	Description	Acre Yield			Percent Sugar	PPM				Beet Count
		Gross Sugar	Tons Beets			Index	Amino N	Na	K	
2	(0v.1 X 712) X 129 RF	5,866	20.18		14.56	551	335	217	1,562	74
12	(S33 X NB-1) X A7111	5,847	19.61		14.92	493	322	224	1,336	63
28	(129 X 0v.3) X 0461 S	5,843	18.42		15.87	672	693	199	1,206	69
34	(S33 X NB-1) X A7135	5,810	19.56		14.83	567	388	226	1,490	74
14	7114 X A7111	5,810	19.89		14.58	536	322	273	1,446	70
7	7114 X 29.002	5,798	19.64		14.75	476	302	206	1,309	73
11	(129 X 0v.2) X A7111	5,758	19.40		14.83	531	329	284	1,430	58
44	(0v.1 X CT5) X 22.005	5,626	20.23		13.89	579	329	273	1,503	73
17	7114 X 28.19	5,611	18.73		14.96	503	372	221	1,207	79
69	Amalgamated check	5,599	19.61		14.25	521	319	224	1,381	75
21	(S33 X NB-1) X 28.19	5,555	17.94		15.46	451	333	173	1,211	71
48	(129 X 0v.1) X 0461 S	5,491	18.17		15.05	481	327	185	1,323	74
20	(0v.1 X CT5B) X L-19	5,465	17.55		15.59	511	368	187	1,450	60
47	(133 X CT5) X 0461 S	5,424	18.48		14.68	484	288	239	1,355	74
32	7114 X 0461 S	5,218	17.22		15.14	575	518	179	1,159	77
27	(129 X 0v.1) X 0461 S	5,179	17.65		14.68	649	598	222	1,096	72
50	(129 X 0v.2) X 0461 S	5,163	17.55		14.70	424	235	174	1,310	70
31	(133 X CT5B) X 0461 S	4,988	16.26		15.34	553	530	177	1,019	68
70	Amalgamated check	4,987	17.58		14.18	531	352	190	1,337	75
8	(133 X 712) X 29.002	4,867	16.47		14.76	530	331	217	1,493	42
Mean of all varieties										
S. E. of mean		6,198	20.29		15.27	535	387	208	1,420	73
L.S.D. (5% point)		267	0.78		0.21	25	26	15	61	3
C.V. %		740	2.16		0.58	69	72	42	169	8
Calculated F		10.55	9.48		3.35	11.58	16.73	17.28	10.47	9.11
		4.98**	4.96**		10.81**	7.15**	9.91**	4.66**	6.55**	5.85**

** Significant at 1% level

Variety Trials for Curly Top Resistance

J. C. Theurer and D. L. Mumford

Six single crosses and their reciprocals were planted in two replicates of 18 feet long single-row plots in the curly top nursery at Hyde Park, Utah, in 1970. The two standard checks, US 33 and US 41, were evaluated in every tenth plot to provide an estimate of the variation in disease severity in the nursery. The number of infected plants were observed and data taken as soon as the more susceptible entries in the nursery reached 100% infection. In addition, two curly top grades were given each entry, one in August and the other in September. The grades were based on a 0-9 scale with 0 indicating no infection and 9 indicating death of all plants.

The mean September grades for the single crosses are shown in Table 1. The crosses CT9 CMS X SLC 127 and CT9 CMS X EL 31 had the same identical grade as their reciprocal cross. The other four entries differed by only .5 of a grade which could possibly be attributed to the individual making the scores, rather than to true differences. The t test showed non-significance at the .05 level. This would indicate that two to four generation backcrosses to a cytoplasmic male sterile resulted in approximately the same equivalent degree of curly top resistance as the original male parent. In comparison to the grades for the single crosses, US 33 was scored 7.0, US 41 6.0, and US 22/3 5.5.

A second variety trial in the curly top nursery consisted of 3-way and 4-way hybrids of the same parentage. The plot description and scoring methods were the same as previously cited. There was little difference between the averages of the females or the pollinators (Table 2). Addition of SLC 133 or CT9 inbreds gave equal or slightly higher curly top resistance compared to the respective 3-way hybrid of like parentage. Inclusion of susceptible lines EL 32 and A7113 on the average showed a slight increase in curly top grades. Based on the brief amount of data in the test it would appear that one or two susceptible lines can be used in 4-way hybrids without materially lowering the curly top resistance.

Fifteen double-cross hybrids and seven of the single-cross parents of these hybrids were also evaluated in the curly top nursery in 1970. Unfortunately seed was not available to have all combinations of the single crosses represented in the double cross hybrids. The planting consisted of three replicates of single-row plots 18 feet long. The entries were scored for curly top in the same manner as previously noted. The mean curly top grade for September, the average of the parental single crosses, and the average of all single crosses having one or more parents in the hybrid are given in Table 3. As expected, single crosses and 4-way hybrids having NB-1, 133, and CT9 resistant inbreds in their

parentage were more resistant than those having susceptible parentage of Ovana, EL 31, or the American Crystal selection A7113. In general the single-cross averages were slightly higher than the actual grades of the 4-way hybrids they were components of. The correlation coefficient for single-cross average vs 4-way hybrids was .70* (significant at 5% level) and .71* for the average of all single crosses having one or more parents in the 4-way hybrid vs the actual 4-way hybrid performance.

It would appear that the more resistant and least resistant double crosses could be predicted from single-cross performance.

Table 1. Curly top resistance of six single cross CMS hybrids and their reciprocals

Description	Curly Top Grade	
	Cross	Reciprocal
CT9 CMS X SLC 133	4.5	4.0
NB-1 CMS X SLC 133	4.5	5.0
Am. Cryst. CMS X SLC 133	5.5	6.0
EL 31 CMS X SLC 133	6.5	7.0
CT9 CMS X SLC 127	6.5	6.5
CT9 CMS X EL 31	5.0	5.0
Mean	5.42	5.58

Calculated $t = 2.72$
 $t_{.05} = 2.78$

Table 2. Mean curly top resistant grade of 3-way hybrids and 4-way hybrids of the same inbred parentage.

Female X Male Parent	Rf	CT9XRf	EL32XRf	A7113XRf	133XRf	OvXRf	Mean
Ov X 712	5.5	5.0	5.5	6.0	-	-	5.5
133 X F.C. 601	5.5	-	-	5.0	-	5.5	5.3
UI 11863X CT7	5.0	5.5	5.0	5.0	4.5	5.0	5.0
UI #7 X 129	4.5	5.0	6.5	5.0	4.5	5.0	5.1
133 X 712	4.5	4.5	5.5	5.5	-	5.5	5.1
Mean	5.0	5.0	5.6	5.3	4.5	5.3	

Table 3. Mean curly top grades for seven single cross and 15 double cross hybrids.

Variety	Mean Curly Top Grade	Avg. Parental single crosses	Avg. All single crosses having one parent of 4-way hybrid
CT9 CMS X 129 Rf	6.0		
133 CMS X 129 Rf	5.7		
CT9 CMS X 201 Rf	6.3		
133 CMS X 201 Rf	6.7		
Ov CMS X EL 31	7.3		
AC CMS X EL 31	8.0		
AC CMS X NB-1	6.3		
(AC CMS X NB-1)X(CT9 CMS X 129Rf)	5.7	6.2	6.4
(Ov CMS X NB-1)X(")	5.3	-	6.3
(Ov CMS X EL 31)X(")	5.7	6.7	6.7
(AC CMS X NB-1)X(133CMS X 129 Rf)	5.3	6.0	6.4
(AC CMS X EL 31)X(")	6.0	6.9	6.7
(Ov CMS X NB-1) X(")	5.3	-	6.3
(Ov CMS X EL 31)X(")	7.0	6.5	6.7
(AC CMS X NB-1)X(CT9 CMS X 201 Rf)	5.7	6.3	6.6
(AC CMS X EL 31)X(")	7.0	7.2	6.9
(Ov CMS X NB-1)X(")	5.7	-	6.5
(Ov CMS X EL 31)X(")	7.0	6.8	6.5
(AC CMS X NB-1)X(133 CMSX 201 Rf)	5.7	6.0	6.6
(AC CMS X EL 31)X(")	6.7	7.4	6.9
(Ov CMS X NB-1) X(")	5.7	-	6.5
(Ov CMS X EL 31)X(")	6.3	6.7	6.7
Average	6.2	6.6	6.6
Correlation coefficients		.70* .71*	.81*

Studies on the Variation of Partial-Male Fertility

J. C. Theurer and E. H. Ottley

Results of experiments by several scientists have shown that the breeding behavior of partial-male fertile sugarbeet lines is difficult to understand or predict and that such lines are greatly affected by environmental factors. Conversely, good type-0 pollinators and good white-anther male-sterile (CMS) lines tend to be quite stable in different environments. Similar results have been observed in other crops such as corn or sorghum. Knowledge of the genetics and breeding behavior of partial-male fertile plants is a real key to answering many questions regarding the inheritance and use of male sterility and partial-male sterility in sugarbeet hybrids.

In 1964 we began a study in our laboratory to observe the variation that occurs in partial-male fertile sugarbeet and to study breeding behavior of progenies derived from a single partial-fertile plant. The results of preliminary experiments were first reported in the 1965 Research Report. Subsequently, a review of pertinent literature and data on additional studies has been prepared for publication (1).

As reported in that manuscript, seven white-anther male-sterile segregates, when crossed to the S_{10} annual type-0 pollinator, SLC 03, gave varied ratios of segregation from 100% male-sterile to 100% partial-fertile offspring. During 1970 an intensive study was made of the fertility of the S_1 progenies of partial-fertile segregates from six of these populations.

Plants were seeded in flats in the greenhouse, then transplanted to 6-inch pots at the 4-leaf stage of development. Six weeks after transplanting they were placed in a cold storage unit at 40 F for 10 weeks for photo-thermal induction. The plants were returned to the 75 F greenhouse and the seedstalk of each plant was bagged with a sno-fiber bag in the early bud stage of flower development. Bags were removed at periodic intervals with one plant at a time in the laboratory and only long enough to check the fertility of each open flower.

Each flower on each branch of a plant was carefully observed and a sample of anthers from every fifth flower was squashed on a slide in a drop of aceto-carmin dye and subsequently observed microscopically for the percentage of stainable pollen.

Seed was harvested individually so as to note the exact placement of each seed on each plant relative to the fertility of the corresponding flower.

RESULTS AND DISCUSSION

A total of 502 plants were studied for fertility patterns. Some populations are represented by a limited number of plants. This is because of the lack of seed originally and the loss of some plants during induction. The data collected in this study is voluminous and only a brief resume will be attempted in this report.

The variation from plant to plant within the same population was very striking and ranged from completely fertile plants to completely male-sterile plants, with all degrees of intra-plant differences. An example of the variation is shown in table 1 for the line 6911-14. Plant 221 had plump yellow anthers, excellent dehiscence, and a good supply of stainable pollen, with little difference in fertility from flower to flower or branch to branch. The sister plant 340 had mostly yellow anthers, fertile and partial-fertile flowers, but also showed random male-sterile flowers or flowers with a very limited supply of stainable pollen. Plant 436 was just about opposite from 340 in that most flowers were male sterile, with scattered partial-fertile flowers. Branch 2 showed more fertility than did the other branches on this plant. While islands of fertility were also observed on other plants, there was no consistent pattern for this behavior in any of the lines. Both the intra-plant and intra-branch variation in fertility appeared to be of random occurrence. Plants 427, 441, and 495 were 100% white-anther male steriles. Such plants in all populations remained sterile throughout the growing period and none of them produced selfed seed.

Classification of the six populations of plants into various fertility categories is given in table 2. With the exception of 6914, all populations showed similar segregation of 50-60% white-anther male-sterile plants. The overall segregation of 266 completely male-sterile plants to 232 plants showing some degree of stainable pollen, fit a 9:7 genetic ratio with a probability of .20 - .30. While partial-male sterility could be attributed to two genetic factors, the reason for the wide variation in fertility between adjacent flowers, branches, or sister plants, remains obscure. A few completely fertile segregates were observed. These will be studied further to be certain of their normal behavior.

The four plants of population 6914 were completely male sterile when first classified and remained such throughout the study. This population has an interesting background. When one male-sterile segregate from the original partial-fertile plant, 9136, was crossed with SLC 03, the 33 offspring were all completely male sterile. However, after clipping back the seedstalk several times and allowing development of new shoots, one small branch on plant no. 14 produced a few flowers with yellow anthers. Four of these flowers set seed which resulted in the four plants observed herein. One of these male steriles has been crossed again with the annual SLC 03 and will be used in future studies.

A detailed comparison of flower fertility versus seed set has not been made to this date. However, general observation indicates there was no direct association with the pollen condition of the flower and seed set. In most cases, seed production was relatively random over the plant, with the terminal and other higher branches producing the greater amount of seed. In some plants there was a considerable difference between branches and a few plants had greater seed set on lower branches. In general, the basal portion and the tip portion of each branch failed to set seed. The greatest amount of seed set was usually observed from the 20th to 40th flower from the base of the branch having an average of approximately 75 flowers per branch. Additional analysis of data and experimental studies are planned with this material.

LITERATURE CITED

1. Theurer, J. C. 1970. Variability in Partial Male Fertile Sugarbeet. J. Amer. Soc. Sugar Beet Technol. (In press)

Table 1. Variation in percent fertility^{1/} for the first 50 flowers on each branch of plants in population 6911-14.

Plant Code No.	Branch ^{2/} of Plant	Flower Number ^{3/}									
		5	10	15	20	25	30	35	40	45	50
221	1	90	90	90	90	90	90	90	90	70	90
	2	90	90	90	90	90	80	80	70	80	80
	3	90	90	90	70	90	80	80	70	70	70
	4	90	90	90	80	80	80	80	80	70	70
	5	90	80	90	90	90	80	80	80	80	80
	6	90	90	90	80	80	90	90	90	80	80
340	1	70	T	T	30	20	20	30	30	50	70
	2	20	20	30	30	60	60	70	80	50	10
	3	50	50	50	70	70	70	70	10	MS	10
	4	70	70	90	80	80	80	80	20	T	T
	5	80	80	80	70	60	60	80	10	10	10
	6	80	80	80	80	50	20	MS	20	20	MS
436	1	MS	MS	T	10	MS	30	T	MS	MS	MS
	2	10	10	20	20	20	MS	MS	-	-	-
	3	T	T	MS	MS	MS	MS	MS	MS	-	-
	4	20	10	MS	MS	MS	MS	MS	MS	MS	MS
	5	T	T	T	MS	MS	MS	MS	MS	MS	MS
	6	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
	7	10	MS	MS	MS	MS	MS	MS	MS	MS	MS
427	1	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
	2	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
	3	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
	4	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
	5	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
441		Similar to -427									
495		"	"	"							

^{1/} T = trace of stainable pollen, MS = no stainable pollen.

^{2/} Terminal branch = 1 other branches numbered in order from top to bottom of seedstalk.

^{3/} Flowers are consecutively numbered from the axil or base of each branch of the seedstalk.

Table 2. Segregation in six S₁ populations of partial-male fertile sugarbeet at Logan, Utah, in 1970.

Line No.	Number of Plants							
	All Flowers MS	MS+ ^{1/} Trace- 25%	MS+ 25- 50%	MS+ 50- 75%	MS+ 75- 90%	All Flowers PF - F	All Flowers Fertile	Total No. Plants
6911-12	1	0	0	0	0	0	0	1
-14	3	0	1	0	1	0	1	6
-18	2	1	0	0	0	1	0	4
Total	6	1	1	0	1	1	1	11
6912-6	1	0	0	0	0	0	0	1
-7	1	0	0	0	1	0	0	2
-8	15	5	0	1	3	3	0	27
-9	6	2	0	1	1	1	0	11
-12	9	0	0	1	2	1	1	14
-14	13	6	1	5	5	0	0	30
-15	12	2	1	3	1	2	0	21
-18	4	1	1	1	0	0	0	7
-21	7	3	0	1	1	0	0	12
-23	20	3	2	1	1	8	0	35
-25	15	8	0	2	1	4	0	30
Total	103	30	5	16	16	19	1	190
6913-2	1	0	0	0	1	0	0	2
-4	11	3	1	0	0	1	0	16
-6	3	0	0	0	0	0	2	5
-18	9	2	0	3	2	3	1	20
-30	2	0	0	0	0	0	0	2
-32	1	1	0	0	0	1	0	3
-37	0	1	0	0	0	0	0	1
-43	3	0	0	0	0	2	0	5
-53	1	0	0	2	0	0	0	3
-54	5	1	0	1	0	2	0	9
-55	1	0	0	0	0	0	0	1
-60	10	1	4	1	0	6	0	22
-67	1	1	0	0	1	1	0	4
-72	18	6	0	5	2	9	1	41
-74	3	2	0	1	0	1	0	7
-77	15	7	1	1	0	2	0	26
-78	5	0	1	0	1	0	0	7
-80	9	1	0	1	2	1	0	14
-81	5	2	1	1	0	2	0	11
-82	5	2	0	0	1	0	0	8

^{1/} Flowers vary in the range from MS to the degree of fertility listed.

Table 2. continued

Line No.	Number of Plants							
	All Flowers MS	MS+ $\frac{1}{\text{Trace-}}$ 25%	MS+ 25- 50%	MS+ 50- 75%	MS+ 75- 90%	All Flowers PF - F	All Flowers Fertile	Total No. Plants
6913-83	8	1	1	2	2	2	0	16
-84	1	0	0	0	0	0	0	1
-85	1	0	0	0	0	1	0	1
-86	4	0	0	0	1	0	0	5
-92	8	3	0	1	2	2	0	16
-93	2	0	0	0	0	0	0	2
-94	0	0	1	0	0	0	0	1
-95	1	1	0	0	0	0	0	2
-98	1	1	0	0	0	0	0	2
-99	1	0	0	0	0	0	0	1
-100	2	1	0	0	0	0	0	3
-101	0	1	0	0	1	1	0	3
-102	1	0	0	0	0	0	0	1
Total	138	38	10	19	15	37	4	261
6914-14	4	0	0	0	0	0	0	4
6915-1	5	1	0	1	0	4	0	11
-7	1	0	0	0	1	0	0	2
-10	6	2	1	0	0	1	0	10
-12	2	2	0	1	0	2	0	7
-13	1	0	0	0	0	0	0	1
Total	15	5	1	2	1	7	0	31
6916-1	3	0	0	0	1	0	0	4
-6	1	0	0	0	0	0	0	1
Total	4	0	0	0	1	0	0	5

^{1/} Flowers vary in the range from MS to the degree of fertility listed.

Virus Investigations

David L. Mumford

Curly Top Disease Nursery

A curly top disease nursery of 2,279 rows was evaluated in 1970. Percentage infection and average grade of each row was sent to all nursery participants. Thirteen standard varieties representing a wide range of reaction to curly top were included in the nursery for demonstration purposes. Data on the reaction of these varieties are included in table 1.

Table 1. Curly top evaluation of standard varieties.

Identification No.	% CT			CT Grade 8-10			CT Grade 9-14		
	R-1	R-2	Av.	R-1	R-2	Av.	R-1	R-2	Av.
SL 129	78	73	76	5	6	5.5	6	6	6.0
NB-1	36	71	54	2	3	2.5	2	4	3.0
O667	50	45	48	4	4	4.0	6	6	6.0
L-35	12	37	25	1	2	1.5	1	2	1.5
L-19	75	93	84	5	8	6.5	8	8	8.0
CT9A	77	83	80	3	4	3.5	5	6	5.5
EL 31	89	94	92	7	7	7.0	7	9	8.0
SL 742	89	100	95	7	8	7.5	8	9	8.5
CT5B	65	69	67	5	4	4.5	5	5	5.0
US 41	88	94	91	5	5	5.0	5	6	5.5
CT 9	100			5			5		
Ovana 11	75	100	88	6	6	6.0	6	7	6.5
22/4	64	71	68	4	5	4.5	5	5	5.0

Correlation of Curly Top Evaluation in Greenhouse and Field

Two hundred ninety one of those sugarbeet lines that were evaluated in the curly top disease nursery were also evaluated in the greenhouse. These lines represented 25 to 50 lines received from each nursery participant. Twenty plants of each line were tested in the greenhouse. Each plant was inoculated when 2 weeks old and evaluated for disease symptoms 5 weeks later.

A highly significant correlation coefficient of .64 was obtained between results of field and greenhouse evaluations. An even higher correlation coefficient of .76 was obtained from an analysis of 78 of the above lines representing those lines receiving the highest and lowest grades in the greenhouse tests. This indicates that identification of curly top resistance can be successfully accomplished in the greenhouse. This is especially true when attempting to distinguish between lines which differ in resistance by 2 or more full points on the grading system.

This year's evaluations in the greenhouse were generally too severe for optimum differentiation between lines. This was probably due to the use of highly virulent isolate 66-10. One of two modifications in the procedure would probably correct this deficiency in greenhouse testing. Either a less virulent isolate of curly top virus could be used for inoculations, or the test plants could be permitted to grow longer before inoculation. The inoculation of older test plants seems to be the more desirable modification and this will be done in any future evaluations.

Virulence of Curly Top Isolates From the Pacific Northwest

Isolates of curly top virus were collected from the sugarbeet areas of Washington, Oregon, and Idaho in 1970. These isolates were transferred in the greenhouse to a susceptible inbred variety of sugarbeet to provide uniformity of virus source material. The virulence of each isolate was evaluated by inoculating both a resistant and a susceptible sugarbeet variety and determining disease reaction.

Two isolates for which disease reaction is known were included for comparison. One isolate was strain 11, described in 1954 as a severe strain from Idaho. The other isolate (66-10) was collected in Utah in 1966 and is highly virulent.

Table 2 presents the average reaction of each isolate on twenty plants of each sugarbeet variety. Isolates are listed in order of increasing virulence on the resistant variety because evaluation seemed to be better on that variety. The overall severity of all isolates on the susceptible variety was so high that differences were thought to be obscured.

Of the 13 isolates evaluated, all but 2 were more virulent on the resistant variety than strain 11. As in previous years, none of the isolates were as virulent as 66-10. However, two isolates approached 66-10 in virulence.

These results support those obtained from similar surveys made in the previous 2 years. They suggest the increased presence of curly top disease potential in the areas surveyed. Data from the 1970 curly top disease nursery indicates that the resistant variety used to evaluate isolates in this survey is the equivalent of 1 to 2 points on the grading scale more resistant than the commercial varieties now used in the areas surveyed. Some of the curly top isolates now being collected are able to cause quite severe symptoms on the resistant variety used in this evaluation. Therefore, if conditions on any given year become unusually favorable for the appearance of abundant viruliferous hoppers in the sugarbeet fields early in the season serious losses would likely result.

Table 2. Virulence of curly top isolates from the Pacific Northwest

Location	Identification No.	Grade ^{a/}	
		NB-1 ^{b/}	3561 ^{c/}
Othello, Washington	70-15	1.0	5.5
Grandview, Washington	70-11	1.0	6.0
Idaho	Strain 11	1.3	7.1
Vale, Oregon	70-6	1.4	6.6
Stanfield, Oregon	70-16	1.6	6.9
S. of Othello, Washington	70-13	1.6	7.6
E. of Othello, Washington	70-12	1.7	7.1
Grandview, Idaho	70-3	2.0	6.6
S. of Walla Walla, Washington	70-8	2.0	7.5
Grandview, Idaho	70-2	2.3	7.5
Umapine, Oregon	70-10	3.0	7.0
W. of Othello, Washington	70-14	3.1	6.7
Vale, Oregon	70-5	4.0	6.9
S. of Walla Walla, Washington	70-7	4.1	7.5
Utah	66-10	4.8	8.4

^{a/} Grades based on scale of 0-9 with 0 = no symptoms and 9 = dead.

^{b/} Resistant variety

^{c/} Susceptible variety

Respiration Rates of Several Sugarbeet Varieties

Roger Wyse

Eight commercial or near commercial varieties adapted to the western sugarbeet growing area were selected for detailed post-harvest evaluation. The objective of this study was to determine the physiological response of these varieties to storage and ultimately to develop methods for evaluating the storage characteristics of a variety either at harvest or after very short-term storage. Only preliminary respiration results are reported here.

Respiration rates of the eight varieties were monitored three times weekly during 70 days of storage at 5 C. Twenty-four beets of each variety were divided into three replications of eight beets each.

The 2.6 fold range between the respiration rates of varieties 1 and 9 represents a substantial difference in potential gross sucrose losses during storage (Table 1). The higher respiration rates were reflected in a higher loss of gross sucrose as determined by chemical analysis. (However, these values were not corrected for raffinose accumulation).

There was no direct relationship between surface area per unit weight and the rate of respiration. Variety 1, although lowest in respiration rate, had the highest surface area per unit weight. This suggests that high surface areas do not contribute to high respiration rates at low temperatures. However, this is undoubtedly not the case at warmer temperatures where diffusive resistance becomes a more dominant factor.

Table 1. Respiration rates of eight sugarbeet varieties stored for 70 days at 5 C.

Variety	Average beet wgt	Surface Area	Respiration Rate	Gross Sucrose Loss
	kg	cm ² /kg	mg/kg hr	lbs/ton
1	.522	596	3.8	12
2	.736	497	6.7	16
3	.741	493	8.4	18
5	.628	543	7.3	16
6	.768	491	6.7	20
8	1.020	444	5.5	24
9	.980	426	9.9	20
10	.792	472	9.7	12

Evaluation of Wax Coatings for Sugarbeet Storage

Roger Wyse

Wax-type coatings have been used successfully to increase the storage life of many vegetable products and prevent wilting of vegetative transplants. Such coatings may be beneficial in preventing or reducing desiccation which occurs on the exterior surface of beet storage piles. To test this possibility, parafin and RD-9, an emulsified wax product of the Mobil Oil Company, were tested for their ability to reduce wilting and/or respiration under controlled conditions.

METHODS

Washed and topped roots were submersed in warm parafin or a diluted RD-9 solution. The RD-9 preparation was diluted either 1-2.5 (W_1) or 1-5 (W_2) before use. Beets stored in 3 mil polyethylene bags containing wet wood chips were used as no-wilt controls when studying chemical changes in the roots.

RESULTS

After 30 days of storage at 5 C in a refrigerator with rapid air circulation, excessive wilting had occurred in both the uncoated control and the RD-9 treated roots. (Table 1). Parafin coating greatly reduced weight loss but did not reduce sucrose losses over storage in polyethylene bags. The rapid air movement apparently caused too severe a treatment to properly evaluate the wax coatings.

The weight-loss experiment was repeated in the lab at 23 C where air circulation was much less. Under these conditions, the wax-coated roots lost 3.9 and 4.1% per day for the W_1 and W_2 treatments respectively compared to 7.1% per day for the untreated control. Parafin-coated roots remained at a constant weight.

Respiration rates at 5 C were not significantly reduced by the RD-9 coatings (Table 2). However, at 23 C respiration rates were reduced by 30%. The lower respiration rates at 23 C were correlated to a lower oxygen concentration inside the roots of the RD-9 treated beets.

The wax coatings appeared to be most beneficial in reducing respiration rates under conditions where rates were high and gaseous diffusion became a dominant factor in regulating respiration rates. Such wax coatings sprayed on surface beets and then covered with straw may be a beneficial combination to prevent desiccation and thus reduce sucrose losses on the surface of commercial storage piles.

Table 1. Desiccation and sucrose losses after 30 days of storage at 5 C.

Storage Treatment	Weight Change	Total Sucrose Loss
	%	lbs/ton
Polybag (no wilt control)	+0.4	12
Parafin	-1.5	12
Wax -1	-22.3	20
Wax -2	-22.7	24
Control (untreated)	-29.1	22

Table 2. Respiration rates and internal air composition of coated and control beets stored at 5 C and 23 C.

	Respiration Rates		Internal Air Composition, 23 C	
	5 C	23 C	CO ₂	O ₂
	mg/kg hr		%	
Control (uncoated)	4.2	42.3	3.9	17.3
W ₁	3.7	29.9	5.5	15.5
W ₂	4.2	31.1	6.3	14.8
Parafin	3.3			

SUGARBEET RESEARCH

1970 Report

Section D

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CONTENTS

Page

SUMMARY OF ACCOMPLISHMENTS	D3
RHIZOCTONIA RESISTANCE BREEDING INVESTIGATIONS, 1970 by J. O. Gaskill and E. G. Ruppel	D10
INHERITANCE OF RHIZOCTONIA RESISTANCE IN SUGARBEET by R. J. Hecker, J. O. Gaskill, and E. G. Ruppel	D11
RHIZOCTONIA RESISTANCE EVALUATION OF CONTRIBUTED SUGARBEET VARIETIES by J. O. Gaskill and E. G. Ruppel	D17
RHIZOCTONIA RESISTANCE EVALUATION OF MISCELLANEOUS SUGARBEET LINES AND HYBRIDS by J. O. Gaskill and E. G. Ruppel. .	D20
EFFECT OF SELECTION FOR RHIZOCTONIA RESISTANCE ON THE MEANS AND VARIANCES OF ROOT YIELD AND SUCROSE by R. J. Hecker and J. O. Gaskill	D22
SUMMARY OF COMPARISONS OF RHIZOCTONIA-LIKE ISOLATES FROM SUGARBEET by E. G. Ruppel	D26
POTENTIAL OF RHIZOCTONIA ISOLATES TO INCITE DAMPING OFF, FOLIAR BLIGHT, AND ROOT ROT IN SUGARBEET by E. G. Ruppel	D27
LONGEVITY OF RHIZOCTONIA ISOLATES UNDER COLD STORAGE by E. G. Ruppel and J. O. Gaskill	D29
DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING MATERIAL AND VARIETIES WITH RESISTANCE TO BOTH LEAF SPOT AND CURLY TOP, 1970 by J. O. Gaskill, E. G. Ruppel, and G. A. Smith . . .	D30
Development of LSR-CTR, Monogerm, Type-0 Populations . . .	D31
Cooperative Tests of LSR-CTR Varieties	D34
VARIABILITY OF SINGLE-SPORE ISOLATES OF CERCOSPORA BETICOLA by E. G. Ruppel	D51
SUGARBEET LEAF AMINO ACIDS AND THEIR ROLE IN CERCOSPORA LEAF SPOT RESISTANCE by G. W. Maag, R. J. Hecker, E. G. Ruppel, J. O. Gaskill, and G. A. Smith	D54

CONTENTS

	Page
THIN JUICE AMINO ACIDS AND OTHER QUALITY CHARACTERS IN LEAF SPOT INFECTED AND NONINFECTED SUGARBEETS by R. J. Hecker, G. W. Maag, E. G. Ruppel, J. O. Gaskill, and P. A. Whitaker	D60
STUDIES ON THE INHERITANCE OF RESISTANCE TO CERCOSPORA LEAF SPOT by G. A. Smith, E. G. Ruppel, and J. O. Gaskill	D67
DIALLEL ANALYSES OF SUGARBEET CHARACTERS by G. A. Smith and R. J. Hecker	D68
STUDIES ON CHEMICAL INDUCTION OF POLLEN STERILITY IN SUGARBEET by D. R. Mason, R. J. Hecker, and G. A. Smith	D68
APOMIXIS SCREENING by G. A. Smith and R. J. Hecker	D71
THE USE OF MITOCHONDRIAL COMPLEMENTATION AS A BREEDING TOOL by G. A. Smith, R. J. Hecker, and G. W. Maag	D71
NITROGEN INVENTORY STUDY OF SUGARBEET THIN AND PRESSED JUICE INCLUDING PERCENT OF INDIVIDUAL AMINO ACIDS by G. W. Maag, R. J. Hecker, and P. A. Whitaker	D73
SUGARBEET LEAF AMINO ACIDS IN DIFFERENT SECTIONS OF THE LEAF AND IN DIFFERENT AGED LEAVES by G. W. Maag, R. J. Hecker, and P. A. Whitaker	D81

SUMMARY OF ACCOMPLISHMENTS, 1970

1. Rhizoctonia Resistance Breeding Investigations, 1970 (J. O. Gaskill and E. G. Ruppel). Results from Experiments R-4, R-5, and R-6 added weight to earlier conclusions that, in F_1 hybrids of resistant x susceptible lines, Rhizoctonia resistance tends toward partial dominance or intermediate levels.

In Experiments R-4 and R-6, the Rhizoctonia resistant lines, FC 701 and FC 702, were consistently superior to their respective source varieties, GW 674-56C and C 817, in Rhizoctonia resistance. Products of additional cycles of selection for resistance (i.e. FC 701/2, FC 701/4, FC 702/2, and FC 702/4) did not indicate significant progress according to evaluations in the respective experiments. In this connection, however, it should be noted that: (1) in both 1969 and 1970, the disease index for FC 701/2 was lower than for FC 701; (2) the average differences in 1969 and 1970 were 0.52 and 0.31, respectively; and (3) the former was significant (5% level).

Evidence obtained in Experiment R-6 and in other 1970 experiments [curly top nursery at Logan, Utah (D. L. Mumford), and leaf spot nursery at Fort Collins] confirmed earlier conclusions (J. O. Gaskill, D. L. Mumford, and E. G. Ruppel) that resistance to leaf spot, curly top, and Rhizoctonia can be genetically combined in sugarbeet lines. One line (entry 937 in Experiment R-6), an F_4 from the cross, FC 901 x SP 631001-0, has resistance to leaf spot, curly top, and Rhizoctonia about equal to that of SP 5481-0, US 41, and FC 701, respectively. It has been assigned the number, FC 801. We are planning, tentatively, to make this line available to the sugarbeet industry, through the Beet Sugar Development Foundation, in the spring of 1971.

2. Inheritance of Resistance to Rhizoctonia Root Rot in Sugarbeet (R. J. Hecker, J. O. Gaskill and E. G. Ruppel). Specific genetic models describing the inheritance of Rhizoctonia resistance in segregating generations of crosses between FC 701/3 (resistant), FC 702/3 (resistant), and FC 901 (susceptible) did not satisfactorily explain the obtained results of the segregating populations (Exp. R-3). However, certain information was derived, namely: (1) both resistant parents exhibited partial dominance for resistance, (2) there was probably more than one major gene conditioning resistance, (3) the two resistant parents did not carry exactly the same genes for resistance, (4) intergenic interactions were probably present and important, and (5) there were probably minor modifying genes present. Estimates of heritability were low but undoubtedly conservative. A significant part of the genetic variance for resistance may have been due to nonadditive gene effects.

3. Effect of Selection for Rhizoctonia Resistance on the Means and Variances of Root Yield and Sucrose (R. J. Hecker and J. O. Gaskill). The root yield and sucrose of Rhizoctonia resistant lines FC 701/2 and FC 702/2 were compared under disease free conditions with each other and their respective source populations GW 674-56C and C 817. Five cycles of mass selection, with as few as two seed producing plants in some generations, reduced the root yield means and variances of FC 701/2 and FC 702/2. These reductions were largely due to inbreeding during the five cycles of mass selection. The relatively low variance for root yield of FC 702/2 could be a disadvantage if it becomes necessary to improve the combining ability of this subline. In comparing the sucrose of FC 701/2 with its source population, GW 674-56C, FC 701/2 was reduced (12.1% vs. 13.0%) by the selection for Rhizoctonia resistance, but the variance was slightly increased (2.39 vs 2.21). The sucrose of FC 702/2 was significantly greater than that of C 817 (13.8% vs. 13.2%). However, the variance was significantly reduced (1.16 vs. 2.07), leaving less potential for sucrose improvement in FC 702/2 than in FC 701/2.

These and other Rhizoctonia resistant sublines, which probably represent the highest levels of resistance in the sugarbeet world, will likely be most useful as sources of genes for resistance. However, in certain areas they may be directly useful as pollinators, particularly since other studies indicate that there is at least partial dominance for Rhizoctonia resistance in crosses with susceptible breeding lines.

4. Summary of Comparisons of Rhizoctonia-Like Isolates from Sugarbeet (E. G. Ruppel). Six isolates from rotted roots, one from a rotted crown, and two from blighted foliage were compared. All had multinucleate hyphal cells, dolipore septa, and hyphal diameters in excess of 5 microns. Pairings of representative isolates of known anastomosis groups with the sugarbeet isolates showed that all root isolates were assignable to anastomosis group (AG) 2, whereas the crown isolate and foliar isolates were assignable to AG 4. Isolates in AG 2 grew from 0.7 to 0.9 cm/day and developed a reddish-brown pigmentation on potato-dextrose agar containing yeast extract. Isolates in AG 4 grew from 1.2 to 1.5 cm/day and were whitish to whitish-tan in appearance. The evidence indicates that the nine sugarbeet isolates are representative of Thanatephorus cucumeris (= Rhizoctonia solani), with the AG 4 isolates belonging to the "practicola" group. However, characterization of the perfect stage is needed for positive taxonomic identification.

5. Potential of Rhizoctonia Isolates to Incite Damping Off, Foliar Blight, and Root Rot in Sugarbeet (E. G. Ruppel). Nine isolates of Rhizoctonia solani were compared. Two foliar isolates and a crown-rot isolate tended to incite more damping off, severe foliar blight, and very little root rot compared to root isolates. The latter, conversely, tended to incite less damping off, little, if any, leaf blight, and severe root rot. Differences among root isolates consisted primarily of variation in virulence as indicated by the nonsignificant isolates x lines interactions in the damping off and root rot experiments. In

both experiments, highly significant differences between lines (susceptible GW 674-56C and resistant FC 701/2) indicated that such tests may be useful to evaluate breeding lines in the greenhouse.

6. Longevity of Rhizoctonia Isolates Under Cold Storage (E. G. Ruppel and J. O. Gaskill). Isolates from partially rotted sugarbeets, grown on moist, whole barley grain for 5 weeks at room temperature and then stored at about -18 C, were still viable and highly pathogenic after 7 years.

7. Development of LSR-CTR, Monogerm, Type-0 Populations (J. O. Gaskill, E. G. Ruppel, and G. A. Smith). Fifty-nine F₃, monogerm, type-0, sugarbeet lines, resulting from a cross between two LSR-CTR, monogerm, type-0 lines which had been developed by means of a backcrossing and selection program, were evaluated in 1970 for: (a) leaf spot resistance at Fort Collins, Colorado, and (b) curly top resistance at Logan, Utah. Of the 59 F₃ lines evaluated, 50 were equal to or lower (i.e. better) than the leaf spot resistant check, SP 5822-0, in average leaf spot grade; 42 were equal to or lower (i.e. better) than the curly top resistant check, US 41, in average curly top grade; and 34 were equal to or lower than both of these standard varieties in the respective disease grades.

The breeding program as a whole, including backcrossing and other procedures involved in the development of the F₃ lines, has been successful in combining the characters, leaf spot resistance, curly top resistance, monogermness, and type-0 in relatively vigorous lines. These F₃ lines represent valuable source material for: (a) selection intended to isolate superior genotypes; and (b) further backcrossing, in which the recurrent parental type will be represented by modern, monogerm, type-0 lines with exceptionally high curly top resistance, high combining ability, and other desirable characters. Work toward these objectives already is under way at Fort Collins.

8. Cooperative Tests of LSR-CTR Varieties (J. O. Gaskill, E. G. Ruppel, and G. A. Smith). Ten hybrid varieties, including an LSR check, a CTR check, and eight varieties having some resistance to both leaf spot and curly top (LSR-CTR), were evaluated by federal, state, and sugar company research personnel in several states in 1970. Because of computer problems, the results of several tests are not available at this time. The following statements are based on data currently available.

Of the eight LSR-CTR varieties, those having FC 506 as the female parent (entries 2, 5, and 7) are of special interest. Average sucrose yields for those three varieties under non-leaf spot conditions (three well-replicated tests in western U.S.), expressed as percent of the sucrose yield of the standard variety (US H20, entry 1), were 113, 110, and 114, respectively. Under severe leaf spot conditions, the corresponding averages were 110, 111, and 110 at Fort Collins, Colo., and 83, 97, and 111 at Beltsville, Md. We suspect that the poor sucrose yields

of entries 2 and 5 at Beltsville were due, in part, to subclinical effects of Aphanomyces cochlioides on plant growth at that location. The high average sucrose yields of entry 7 (FC 506 x McF. 413) under both non-leaf spot and leaf spot conditions is especially impressive. Average sucrose percentages for entries 2, 5, and 7, expressed as percent-of-standard, were 108, 108, and 106, respectively, under non-leaf spot conditions, and 107, 114, 113, respectively, under leaf spot conditions.

The outstanding performance of the LSR check (entry 9, FC 506 x SP 6322-0) at Beltsville, Md., is of special interest. The percent-of-standard averages for that variety at Beltsville were 132 and 114 for sucrose yield and sucrose percentage, respectively. These results were in line with performance of that variety at Fremont and Old Fort, Ohio (see other reports).

Although FC 506 is not resistant to curly top, its high resistance to leaf spot and good combining ability make it especially promising for use in various hybrid combinations.

Entry 8, an LSR-CTR-Rhizoctonia resistant hybrid, deserves special mention. According to the 1970 results, it has moderate leaf spot and Rhizoctonia resistance, and curly top resistance about equal to that of US H9B. Under non-leaf spot conditions in 1970 (three tests) its percent-of-standard averages were 111 and 107 for sucrose yield and sucrose percentage, respectively. Under leaf spot conditions (two tests) the corresponding averages were 103 and 110. These results suggest that the Rhizoctonia resistant lines, FC 701/2 and FC 702/2, may be useful as pollinators in the production of LSR-CTR-Rhizoctonia resistant hybrids with satisfactory agronomic characters.

9. Variability of Single-Spore Isolates of Cercospora beticola (E.G. Ruppel). Significant differences among several Cercospora beticola isolates in spore production, spore morphology, and relative pathogenicity indicate that variant races of the fungus exist in Colorado. However, in pathogenicity tests with sugarbeet lines varying in leaf spot resistance, the lines x isolates interaction always was nonsignificant. Thus, in Colorado, lines selected for resistance to Cercospora should be resistant to most isolates from within the state.

10. Sugarbeet Leaf Amino Acids and Their Role in Cercospora Leaf Spot Resistance (G. W. Maag, R. J. Hecker, E. G. Ruppel, J. O. Gaskill, and G. A. Smith). A 1970 experiment was designed to continue the 1968-69 study of leaf amino acids and their possible role in Cercospora leaf spot resistance.

Three heterogeneous, one inbred, and two hybrid sugarbeet varieties were selected to give a wide range in Cercospora leaf spot resistance. Duplicate plantings of the six populations with three replications were made at two locations, the Agronomy Research Center (disease free) and the Disease Farm Nursery. The plants at the Disease Farm Nursery were inoculated with Cercospora beticola.

Leaves were harvested from each location on three dates during the summer as the Cercospora infection progressed at the Disease Nursery. Individual plot leaf samples will be analyzed for amino acids and amides using an amino acid analyzer. The phenolic compound, 3-hydroxytyramine, is included in the study. Two leaf spot readings were made during the summer.

To determine the effect of Cercospora infection on sugarbeet quality, the roots were harvested at both locations on the ~~same~~ day. Root factors were determined and phosphated thin juice prepared. We will determine the free amino acids and amides, total nitrogen, amino nitrogen, nitrate nitrogen, betaine, chlorides, sodium, potassium, and possibly other chemical components of the thin juice on individual plot basis.

11. Thin Juice Amino Acids and Other Quality Characters in Leaf Spot Infected and Noninfected Sugarbeets (R. J. Hecker, G. W. Maag, E. G. Ruppel, J. O. Gaskill, and P. A. Whitaker). Eight populations, ranging from highly leaf spot susceptible to resistant, ~~were~~ studied for quality comparisons under diseased and disease-free conditions. Severe leaf spot infection contributed to a serious reduction in root yield and sucrose, particularly in susceptible lines. Thin juice purity was slightly higher in the diseased plots, on the average, but there was considerable interaction of genotype with disease. There was, without exception, more sodium in the thin juice of diseased plots but less total nitrogen, amino nitrogen, and betaine. Eighteen individual amino acids and ammonia were quantitatively determined in the thin juice of four populations. The quantity of these nonsugars was generally lower in the diseased plots of three populations (resistant and susceptible). One highly susceptible inbred showed an increase in 10 of the 19 characters. Among the populations studied, leaf spot infection primarily took its toll through decreased yield and sucrose without necessarily affecting quality. With respect to relationships of amino acids and inherent leaf spot resistance, the resistant variety US 201 and the susceptible variety ~~M~~ & G Pioneer were almost identical in quantity of amino acids whether diseased or disease-free. Hence, there appeared to be no predictable relationship between leaf spot resistance and individual amino acids in the thin juice of roots at harvest.

12. Studies on the Inheritance of Resistance to Cercospora Leaf Spot (G. A. Smith, E. G. Ruppel, and J. O. Gaskill). F_2 populations of crosses between resistant US 201 and susceptible inbred lines 52-334 and 51-319 were grown under artificially induced leaf spot epidemic. Leaf spot ratings were obtained on 310 randomly chosen plants from each F_2 population. F_3 lines are to be developed from these selected disease rated F_2 plants for use in computing narrow sense heritability estimates and further estimates of gene number. Eighty plants displaying high resistance and 80 displaying low resistance were selected from each F_2 population. These plants will be used to produce interpollinated populations from which the accuracy of heritability estimates can be determined by comparison of actual and predicted selection gain.

13. Diallel Analyses of Sugarbeet Characters (G. A. Smith and R. J. Hecker). Twenty-eight F_1 hybrids from the diallel mating of 8 inbred lines were grown in the field along with their parental lines. Root weight, top weight, sucrose, purity and recoverable sugar were determined in the 8-replicate experiment under 0 and 250 lbs of nitrogen. Diallel analyses are being performed for each character to determine the type of gene action controlling the character and the effect of N fertility on this gene action. The same diallel set is being developed to be grown in 1971 so that the effect of environment (year and fertility) on the expression of the genes can be determined.

14. Studies on Chemical Induction of Pollen Sterility in Sugarbeet (Dianne R. Mason, R. J. Hecker, and G. A. Smith). A greenhouse experiment was conducted to compare the male sterility effects of oestrone, arsenic acid and Ethrel. Ethrel was the only one showing any promise of male sterility induction, and then only in an inbred variety. A subsequent field test of Ethrel on two vigorous open-pollinated varieties, showed a reduction in pollen viability of the 200 ppm treated plants (39% and 64% viable pollen in the two varieties compared to 84% for controls). It is felt that further studies with Ethrel are warranted.

15. Apomixis Screening (G. A. Smith and R. J. Hecker). From 35 different source populations we have found several lines which are currently in the third cycle of screening for apomictic behavior. These lines are being subjected to further controlled pollination and then will be examined critically by floral emasculation and embryo-sac analyses. In addition, two Michigan lines from O_2 clone sublines were found which are now entering a second cycle of screening.

16. Mitochondrial Complementation as a Breeding Tool (G. A. Smith, R. J. Hecker and G. W. Maag). Work was begun to determine the correct mitochondrial extraction procedure in sugarbeet. Mitochondria were extracted from wheat by centrifugation and placed in a buffered reaction mixture. After addition of a substrate AKG (alpha-ketoglutarate) and ADP (adenosine diphosphate), changes in oxygen consumption were measured with a biological oxygen monitor, utilizing a Clark-type platinum silver electrode. Mitochondrial activity was measured at 27°C in the presence of ADP and AKG. Work has progressed well enough on the "known" wheat reaction to begin application of the same procedure to sugarbeet.

17. Nitrogen Inventory Study of Sugarbeet Thin and Pressed Juice Including Percent of Individual Amino Acids (G. W. Maag, R. J. Hecker, and P. A. Whitaker). Thin and pressed juice samples from 6 replications of one population, GW 359-52R, grown at 3 nitrogen fertility levels were analyzed for nitrogen components, including individual free amino acids and amides. Twenty-one amino acids plus two amides were identified and quantitatively determined as well as the percentage of each amino acid. The amount of nitrogen in these amino acids and amides was also calculated. Analyses for ammonium nitrogen, nitrate nitrogen, betaine nitrogen, amino nitrogen, and total nitrogen (Kjeldahl) is included in the study with some non-nitrogen anion and cation components.

Glutamic acid (including converted glutamine and pyrrolidone carboxylic acid) made up from 58.4 to 59.6 percent of the total known amino acids. Percentage of aspartic acid and gamma-aminobutyric acid ranked second and third, respectively. Amino acid nitrogen (including nitrogen from the amides and PCA) ranked highest in nitrogen source amount with betaine nitrogen ranking second. Additional work is being done on this sugarbeet juice inventory study.

18. Sugarbeet Leaf Amino Acids in Different Sections of the Leaf and in Different Aged Leaves (G. W. Maag, R. J. Hecker and P. A. Whitaker). Free amino acids were determined using an amino acid analyzer in 3 different ages of sugarbeet leaves and in 3 different transverse sections of the leaves of two heterogeneous and two inbred varieties to aid us in selecting the best sampling technique for research work involving sugarbeet leaf amino acids.

Twenty-one free amino acids and two amides were identified, quantitatively determined, and the results compared. Several unknown amino acids or analogues were also present. The amino acid content of the different aged leaves and different sections of the leaves showed considerable variation. Some difference was also evident in the different varieties. Based upon all results, the medium aged leaf is the most representative leaf and the transverse mid-section of the leaf is the most representative part of the leaf. It is advisable that the same person(s) do the leaf sample harvesting each time.

RHIZOCTONIA RESISTANCE BREEDING INVESTIGATIONS, 1970

Introduction

J. O. Gaskill and E. G. Ruppel

With increased financial support from the Beet Sugar Development Foundation, breeding-oriented research on Rhizoctonia was expanded considerably in 1970. Field plot work for (a) evaluation of Rhizoctonia resistance of breeding lines, experimental hybrids, and miscellaneous varieties; (b) study of inheritance of resistance; and (c) selection of mother beets for resistance, was conducted in a 1.5-acre, sprinkler-irrigated field on the Warren Tract near the CSU Agronomy Research Center. The following experiments, in addition to several selection blocks, were included in the Rhizoctonia field:

- R-1: Interaction of sugarbeet varieties x Rhizoctonia isolates.
- R-2: Inoculation methods study.
- R-3: Inheritance of Rhizoctonia resistance (R.J. Hecker, leader).
- R-4: Evaluation of resistance of contributed varieties.
- R-5: Cooperative test of LSR-CTR varieties.
- R-6: Evaluation of resistance of miscellaneous lines and hybrids.
- R-7: Test of individual-plant progenies.

The field included more than 900 plots (each consisting of one 20-foot row) plus several selection blocks totaling more than 3,000 feet of row. All plants in all plots and selection blocks were inoculated with Rhizoctonia. With the exception of Experiment R-2, the rosette method of inoculation was used throughout. Isolate B-6 was used for all inoculations except in Experiment R-1 in which five isolates were compared.

With minor exceptions, all inoculum used in the 1970 field was prepared in 1970. Inoculum of isolate B-6, prepared a year earlier and stored in a refrigerator, was used in part of the selection area and in a special comparison of 1969 and 1970 B-6 inoculum. The results showed quite clearly that the 1970 inoculum was less virulent than the 1969 inoculum. The general level of disease intensity in the 1970 plots was lower than usual. This was attributed primarily to the lower virulence of the 1970 inoculum. The causes of lower virulence of that inoculum are being investigated.

Experiment R-1 involved five sugarbeet varieties and five Rhizoctonia isolates, in all possible combinations, with five replications. Disease intensity in this experiment was too low for valid conclusions. After harvesting two replications, the experiment was abandoned.

Experiment R-2 included side-dressing inoculation at two dates (2 and 4 weeks after thinning), with two rates of application at each date.

The rosette inoculation method served as a standard. Two varieties were used: (a) the Rhizoctonia resistant variety, FC 701/4; and (b) its susceptible source, GW 674-56C. Very little disease, with negligible varietal differences, resulted from side-dressing inoculations, except for the heavy rate 4 weeks after thinning (treatment D). That treatment caused much more severe attack than the other three side-dressing treatments but much less than the rosette inoculation method (treatment E). Treatments D and E agreed in that the varietal difference in each case, indicating higher resistance for FC 701/4, was greater than the 1% level of significance. On the basis of earlier methods studies, we believe that the relatively low level of disease intensity resulting from the side-dressing treatments in Experiment R-2 was due, in part, to the low virulence of the 1970 inoculum used (see above). Other factors may have been involved. We consider the results inconclusive, as a whole. However, they may be helpful in planning future experiments of this type.

Results of Experiments R-3, R-4, and R-6 are presented in separate reports accompanying this introduction. Experiment R-7 served to evaluate individual-plant progenies for Rhizoctonia resistance and afforded an opportunity for selection of individual plants for resistance in the better progenies. The results of that experiment are not presented herein.

Results of Experiment R-5 are included in the set of reports on the cooperative tests of LSR-CTR varieties under the general heading, "DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING MATERIAL AND VARIETIES WITH RESISTANCE TO BOTH LEAF SPOT AND CURLY TOP, 1970". The high light in the set of data reported for Experiment R-5 is the performance shown for entry no. 8 [(FC 602 x SP 652016sl) x FC 701/2 and FC 702/2], the only entry having any background of Rhizoctonia resistance breeding. Entry 8 was significantly superior to all others in Rhizoctonia resistance, as measured by both disease index and percentage of healthy plants. This occurrence is of special interest in view of the fact that the female parent of entry 8 (i.e. FC 602 x SP 652016sl) is known to be quite susceptible to Rhizoctonia (see report for Experiment R-6, entry 920).

INHERITANCE OF RHIZOCTONIA RESISTANCE IN SUGARBEET

Experiment R-3

R. J. Hecker, J. O. Gaskill, and E. G. Ruppel

Through the past several years Mr. Gaskill has developed sugarbeet lines with Rhizoctonia resistance. Using two of his most resistant lines and a susceptible line, F₁'s, backcrosses, and F₂'s were developed and evaluated for Rhizoctonia resistance in an attempt to describe more completely the inheritance and genetic control of resistance. Such information would be of considerable value in breeding for resistance since it would indicate to the breeder the methods of selection and breeding which are likely to be the most efficient.

Materials and Methods

The 11 sugarbeet strains or varieties listed in Table 1 were grown in a randomized complete block experiment at our disease nursery (Warren Tract) in 1970. The 20-foot single row plots were 22 inches apart and replicated 14 times. Plants were thinned to about 10 inches in the row. Stands were adequate after about 30 seedling plants were transplanted within the rows of entry 857. We assumed this would not affect the degree of resistance at harvest. All plants were inoculated by the rosette method with R. solani 4 weeks after thinning. Isolate B-6, which has previously been highly pathogenic, was used. This year, the virulence of the fungus was reduced, apparently due to a difference in the preparation procedure. In order to avoid excessive drying of the inoculum, the experimental area was sprinkler irrigated for a 4-hour period on July 15, immediately after completion of the inoculation job, and for a 2-hour period on each of the days, July 16, 17, and 18. Rainfall of 1.15" and 0.30" occurred on July 19 and 22, respectively, obviating sprinkler irrigation. Before and after the period, July 15-22, inclusive, sprinkler irrigation was performed essentially to supply the moisture needs of the crop. At harvest, each plant was lifted (17 per plot, 238 per population), rated for disease, and classed for size. The Rhizoctonia grades were essentially the same as described and pictured in our 1969 report, i.e., 0 = disease free, to 5 = dead.

Adjustment of Rhizoctonia Grades for Root Size

From experience and observation we believe that with our grading system, large roots may receive a lower disease grade than their actual resistance level might warrant. Hence, high-yield varieties would tend to be graded lower than their actual level of resistance.

In an attempt to reduce this size-grade relationship, grade adjustments based on root size were made. Each root was visually classified as size 1, 2, or 3; approximately up to 1 lb., 1 to 2 lb., and over 2 lb., respectively. The disease grade of size 2 and 3 roots then was increased by .33 and .67, respectively. For example, a size 1-grade 3 root remained grade 3, size 2-grade 3 became 3.33, and size 3-grade 3 became 3.67. It is apparent by comparing indices of different size classes in Table 1, particularly for the susceptible entries 853 and 861, that this adjustment for size did not entirely eliminate the size-grade relationship. However, over-adjustment was possible when one considers that in the resistant entries the size-grade relationship is the inverse of susceptible entries (large roots graded highest). We need to give further thought to this problem of obtaining a disease index which is an absolute indicator of resistance. However, it was our opinion that this adjustment improved the direct comparability of the disease indices. More severe adjustments and certain transformations were examined, but the fear of over-discrimination against size led us to use the size adjustment described above. All disease index means, variances, and other calculations in this report were based on adjusted data.

Heritability Estimates for Resistance

Heritability (h^2) is the degree to which the characteristics of a plant are repeated in its progeny. Hence the magnitude of h^2 should indicate the relative effectiveness of selection and breeding for a particular character.

From the variances in Table 2, broad sense (ratio of all the genetic variance to the total variance) and narrow sense (ratio of only the additive genetic variance to the total variance) h^2 's can be computed.

There are two problems which first need to be considered.

- (1) The within-plot variances in Table 2 are heterogeneous. This heterogeneity is due to a mean-variance relationship which is not removable by data transformation. Hence direct estimation of environmental variances is impossible.
- (2) The parents, FC 701/3, FC 702/3, and FC 901, probably are not completely homozygous for resistance and susceptibility. This would cause h^2 estimates to be reduced, hence, conservative.

Since there was an apparent relation between means and variances it was tested in the "nonsegregating" parents and F_1 's (entries 851 through 855). The correlation of means and within-plot variances was .99 (significant at 1%). The linear regression equation $\hat{s}_e^2 = 1.0784\bar{X} - .1145$ was then used to estimate the environmental variances of the "segregating" populations. The differences between these variances and the within-plot variances were used to estimate the total genetic variances in Table 2. The h^2 's in Table 2 are, therefore, broad sense heritabilities. Ranging from .30 to .08, the h^2 's seem to be quite low. Also, an estimation of genetic advance of FC 701/3, which resulted from five cycles of mass selection starting from GW 674-56C, indicates that at $h^2 = .12$ (assuming h^2 for GW 674-56C is entirely due to additive genetic variance) the genetic advance exhibited in FC 701/3 was greater than expected. Hence, genetic improvement for resistance was more rapid than would be theoretically expected if the variances and h^2 's in Table 2 were accurate estimates. The conservative nature of the h^2 's in Table 2 could account for this discrepancy. From methods of Mather and Powers it is also possible (in the F_2 and backcrosses of FC 901 x FC 701/3) to estimate relative proportions of additive and nonadditive genetic variance. The one possible estimate was that 56% of the total genetic variance was due to the additive effects of genes conditioning Rhizoctonia resistance.

From the estimates of h^2 and this proportion of additive genetic variance, it appears that improvement of resistance should be slow, with maximum resistance attained by capitalizing on dominance and/or interlocus interaction effects. The progress that already has been made by mass selection, and the frequency of relatively resistant F_3 lines, previously demonstrated, indicate that our heritability estimates are conservative.

Genetic Models

The estimate that only 56% of all genetic variance is additive and the disease-index means in Table 1 indicate that: (1) lines FC 701/3 and FC 702/3 do not have the same genes or gene frequencies for resistance (either different alleles or different loci may be involved); (2) there is partial dominance for resistance in both these resistant parents, but the degree may be different; and (3) there must be more than one locus for resistance, with interaction of these loci likely (epistasis).

In consideration of these conditions, 12 basic genetic models, and several modifications of each were postulated and tested against obtained disease index means and genetic variances. A two-locus model was finally developed for each parent, FC 701/3, FC 702/3, and FC 901; these three models were only marginally satisfactory and were somewhat complex. Table 3 describes the models and compares obtained and theoretic means and genetic variances.

The theoretic means (means computed from the given model) were not significantly (5%) different from the obtained means, but it should be remembered that the genetic models were, in a way, "made to fit". The theoretic genetic variances (variances computed from the genetic model in Table 3) were lower than the obtained genetic variances in four of the five segregating populations.

In general, the models did not provide a very satisfactory explanation of obtained data. More complex models could be developed but would probably be no more authentic because of the two problems which exist in the data: (1) probable heterogeneity of parents, and (2) the inability to achieve homogeneous variances.

The character "% diseased" (Table 1) was tested as a qualitative genetic factor but, like disease index, it was not explainable in a relatively simple Mendelian manner. The main problem was probably due to considerable misclassification of plants in disease grades 1 and 2 (particularly plants classed as grade 1 when they should have been grade 2) which resulted from the low intensity of disease.

Despite an inability to precisely describe the inheritance and genetic control of Rhizoctonia resistance in the populations studied, the data do provide some genetic information. (1) There is probably partial dominance for resistance in both FC 701/3 and FC 702/3, with the latter exhibiting the greatest degree of dominance. This suggests that Rhizoctonia-resistant lines used as pollinators might impart considerable resistance to hybrids, eliminating or reducing the necessity of having resistance in all parents of a hybrid. This would be a capitalization on the nonadditive genetic variance component. (2) There appears to be more than one major locus for resistance, particularly in FC 701/3, but probably also in FC 702/3. This increases the difficulty of breeding for resistance but enhances the ultimate potential. (3) It

is likely that FC 701/3 and FC 702/3 do not carry the same major genes, or alleles, for resistance. This implies that even higher levels of resistance might be obtainable among the segregants of FC 701/3 x FC 702/3, and that still other genes for resistance probably exist in the species. Our study does not indicate whether the differences between FC 701/3 and FC 702/3 are genic (locus) or allelic. The latter would reduce the possibility of superior recombinants and, perhaps, reduce the likelihood of other resistance genes in other germ plasm sources within the species. (4) Interlocus interactions are likely, thereby enhancing the possibility of specific genetic combinations being necessary for maximum resistance and at the same time increasing the complexity of achieving maximum resistance. (5) There are probably minor or modifying genes present which would make it difficult to isolate the major genes for resistance. (6) From other experiments, it would appear that there may be no serious genotype by environment interactions.

In general, it appears that Rhizoctonia resistance is relatively simple in its inheritance, with significant potential for exploitation of nonadditive gene action. A precise explanation of inheritance probably must await the development of more homogenous parents and a means of grading resistance which eliminates or allows circumvention of the problem of heterogeneous variances.

Table 1. Disease indices, % living, and % diseased sugarbeets in an inheritance study of Rhizoctonia resistance, 1970.^{1/}

Entry no.	Population	% Living	% Diseased ^{3/}	Disease Index ^{2/}			
				Root size			All
				1	2	3	
851	FC 701/3(Rhizoc.resistant)	100.0	11.8 g ^{4/}	.80	1.20	1.06	.95 ^{4/} e
852	FC 702/3(" ")	100.0	12.2 g	.73	1.57	2.17	.86 e
853	FC 901(Rhizoc.susceptible)	76.9	57.6 a	2.80	1.93	1.67	2.61 a
854	FC 901 x FC 701/3, F ₁	98.7	22.3 f	1.41	1.30	1.42	1.36 cd
855	FC 901 x FC 702/3, F ₁	99.6	12.2 g	1.05	1.02	1.96	1.07 de
856	FC 901x(FC 901xFC 701/3,F ₁)	83.2	47.9 b	2.53	1.76	1.88	2.27 b
857	(FC 901 x FC 701/3,F ₁) x FC 701/3	97.5	25.2 ef	1.37	1.48	1.14	1.40 c
858	FC 901 x FC 701/3, F ₂	93.3	30.3 c	1.71	1.54	1.55	1.64 c
859	FC 901 x FC 702/3, F ₂	93.7	25.6 de	1.55	1.47	.84	1.53 c
860	FC 901 x(FC 901xFC702/3,F ₁)	94.5	28.6 cd	1.64	1.57	1.52	1.61 c
861	GW 674-56C	86.1	45.0 b	2.45	1.79	1.34	2.14 b

- ^{1/} Planted May 18-19, inoculated July 14-15, and harvested October 1-2.
^{2/} Disease index based on a scale of 0 to 5; 0 = healthy, 5 = dead, with adjustment for size as described in the text.
^{3/} Those plants with a disease rating ≥ 2 .
^{4/} Means followed by the same letter are not significantly different at the 5% level.

Table 2. Within-plot variances, estimated environmental variances, estimated genetic variances, and broad sense heritability ratios for disease grade in an inheritance study of Rhizoctonia resistance, 1970

Entry no.	Population	Within plot variance	Est. env. var. ^{1/}	Total genetic variance	h^2
851	FC 701/3	.873			
852	FC 702/3	.9424			
853	FC 901	2.703			
854	FC 901 x FC 701/3, F_1	1.4152			
855	FC 901 x FC 702/3, F_1	.8809			
856	FC 901 x (FC 901 x FC 701/3, F_1)	3.0048	2.3335	.6713	.22
857	(FC 901 x FC 701/3, F_1) x FC 701/3	1.5221	1.3953	.1268	.08
858	FC 901 x FC 701/3, F_2	2.2746	1.6541	.6205	.27
859	FC 901 x FC 702/3, F_2	2.1834	1.5355	.6479	.30
860	FC 901 x (FC 901 x FC 702/3, F_1)	1.9148	1.6109	.3039	.16
861	GW 674-56C	2.5000	2.1933	.3067	.12

^{1/} Environmental variances estimated from the regression equation $\hat{s}_e^2 = 1.0784\bar{X} - .1145$.

Table 3. Comparison of obtained and theoretic means and genetic variances for disease index in the Rhizoctonia resistance inheritance study, 1970.

Model and Population	Mean		Genetic variance	
	Obtained	Theoretic	Obtained	Theoretic
FC 701/3 = A_1A_1BB , FC 901 = $aabb$; first A_1 or B equal and additive with effect of -.415; first A_1 and B together interact for -.83 effect but are hypostatic to a or b; second A_1 and B together interact for -.415 effect.				
F_1	1.36 \pm .15	1.36		
F_2	1.64 \pm .19	1.72	.6205	.1945
BC to FC 901	2.27 \pm .22	2.19	.6713	.2063
BC to FC 701/3	1.40 \pm .16	1.36	.1268	.1186

FC 702/3 = A_2A_2BB , FC 901 = $aabb$; first A_2 or B equal and additive for -.97 effect; second A_2 or B each -.11 except they are hypostatic to the first A_2 and B.				
F_1	1.07 \pm .12	1.07		
F_2	1.53 \pm .19	1.35	.6479	.1869
BC to FC 901	1.61 \pm .18	1.74	.3039	.3064

RHIZOCTONIA RESISTANCE EVALUATION OF
CONTRIBUTED SUGARBEET VARIETIES

Experiment R-4

J. O. Gaskill and E. G. Ruppel

Thirty-six sugarbeet hybrids, breeding lines, etc. (so-called "varieties"), from breeding stations at 9 locations in the United States and Canada, were evaluated for resistance to Rhizoctonia root and crown rot in a field experiment at Fort Collins, Colorado, in 1970. The experiment consisted of 1-row x 20-foot plots (rows 22 inches apart) and six replications with an equalized-random-block design. Planting was performed on May 18-19. The plants were thinned by hand, to a spacing of 10-12 inches in the row, approximately 4 weeks later. Inoculation was performed on July 14-15 by means of the rosette method previously described, using R. solani isolate B-6 (1).

At harvest (October 6-20), all plants in a 17-foot section of each plot were dug by hand and rated individually for disease severity. The ratings were based on the scale, 0 = essentially healthy, and 5 = dead, as illustrated in Figure 1, page D13, of Sugarbeet Research, 1969 Report.

The results, as shown in Table 1, were intended primarily to inform the respective contributors as to the Rhizoctonia resistance of the varieties that they furnished. However, the data also afford an opportunity to note the resistance of a number of F₁ hybrids having FC 701/2 or FC 702/2 as the male parent. The female parents of most of those hybrids were not included in the experiment. However, results previously obtained at Fort Collins--both published (1) and unpublished--and at East Lansing, Michigan, (3) have led us to the conclusion that it is highly improbable that any of those female lines are resistant to Rhizoctonia. The relatively substantial degree of resistance shown by the F₁ hybrids is in keeping with results previously obtained at Fort Collins (2). Four varieties, including two F₁ hybrids, are shown in Figure 1.

As was to be expected, FC 701 and its derivatives were significantly superior to their source variety, GW 674-56C, in Rhizoctonia resistance. Likewise, FC 702 and its derivatives were significantly superior to their source variety, C 817. There were no significant differences: (a) among FC 701, FC 701/2, and FC 701/4; or (b) among FC 702, FC 702/2, and FC 702/4.

Literature Cited

- (1) Gaskill, J. O. 1968. Breeding for Rhizoctonia resistance in sugarbeet. J. Amer. Soc. Sugar Beet Technol. 15(2): 107-119.
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- (3) Schneider, C. L. 1969. A review of the Rhizoctonia crown and root rot disease of sugarbeet. Proc. 15th Regional Meeting (Eastern U.S. and Eastern Canada) Amer. Soc. Sugar Beet Technol. pp. 27-30.

RHIZOCTONIA RESISTANCE EVALUATION OF MISCELLANEOUS
SUGARBEET LINES AND HYBRIDS

Experiment R-6

J. O. Gaskill and E. G. Ruppel

Forty sugarbeet lines and hybrids were evaluated for Rhizoctonia resistance in the field in a manner similar to that described for Experiment R-4. The summarized results are presented in Table 1, and a line contrast is shown in Figure 1.

All of the FC 701 lines (entries 907-911, inclusive) were significantly superior to their source variety, GW 674-56C (entry 906), in Rhizoctonia resistance. Likewise, all of the FC 702 lines (entries 913-917) were significantly superior to their source variety, C 817 (entry 912). With one exception, there were no significant differences (a) among the FC 701 lines, or (b) among the FC 702 lines. These statements are based on both types of results shown--i.e., in the "Disease index" and the "Healthy (%)" columns in Table 1. These observations were in agreement with results obtained from Experiment R-4.

Each of the entries, 927-932, is a product resulting from pooling of lines derived from both GW 674-56C and C817. Each of the entries, 927-932, was significantly superior to GW 674-56C (entry 906) and C 817 (entry 912) in disease index and in percentage of healthy plants. Although none of the entries, 927-932, differed significantly from any of the FC 701 and FC 702 lines, they are of special interest because of the broader base from which they were derived. Further selection in these lines, for Rhizoctonia resistance, seems highly desirable.

Entries 935-940 are products of an attempt to combine resistance to leaf spot, curly top, and Rhizoctonia. Progress in this undertaking has been reported (see literature citation no. 2 in our report for Experiment R-4). All but one of the entries, 935-940, were significantly superior to the Rhizoctonia susceptible parent, FC 901 (entry 933), in disease index and percentage of healthy plants. Most of them, including entry 937, were about equal to FC 701 and FC 702. Entry 937, shown in Figure 1, is of special interest because, in addition to its Rhizoctonia resistance, it has resistance to leaf spot and curly top about equal to that of SP 5481-0 and US 41, respectively. It is a relatively vigorous line. We have no information regarding its sucrose percentage. It has been assigned the number, FC 801. We plan, tentatively, to make it available to the sugarbeet industry, through the Beet Sugar Development Foundation, in the spring of 1971.

Entries 921-926 are F₁ hybrids having a Rhizoctonia susceptible CMS line or hybrid (see entries 918-920) as the ♀ parent and a Rhizoctonia resistant line (FC 701/2 or FC 702/2) as the ♂ parent. In disease index, each F₁ was significantly superior to its susceptible parent. In percentage of healthy plants, the average for each F₁ was higher than that of the corresponding susceptible parent. In three of the six cases the differences were significant. These results were in agreement with those obtained in Experiments R-3 and R-4.

1/ Contributors:

- A -- American Crystal Sugar Company
- B -- Amalgamated Sugar Company
- C -- Canadian Sugar Factories, Ltd.
- D -- Farmers & Manufacturers Beet Sugar Association and the
East Lansing, Michigan, and Beltsville, Maryland
stations of U.S.D.A.
- E -- Great Western Sugar Company
- F -- Holly Sugar Corporation
- G -- Spreckels Sugar Company
- H -- Utah-Idaho Sugar Company
- I -- U.S. Department of Agriculture, Fort Collins, Colorado

2/ The *Rhizoctonia* resistant varieties, FC 701, FC 702, and their derivatives were not involved in the parentage of the varieties in this test except where specifically indicated in this table.

3/ Disease index based on the scale, 0 = essentially healthy and 5 = dead. Means followed by the same letter are not significantly different, according to Duncan's multiple range test (5% level).

4/ Percentage of population classed as essentially healthy. Bliss' transformation (to degrees) was used for summarization, analysis of variance, and Duncan's multiple range test. According to that test, means followed by the same letter are not significantly different (5% level).



Fig. 1. Comparison of *Rhizoctonia* resistance of four sugarbeet varieties in 1-row plots, Fort Collins, Colo., Exp. R-4, 10/3/70 (left to right): (a) SP 471001-0 (border row); (b) entry 811, an F_1 hybrid; (c) entry 809, an F_1 hybrid; and (d) entry 829, GW 674-56C. The σ parent of both F_1 hybrids is the *Rhizoctonia* resistant line, FC 701/2. (Photo. 207-23)

RHIZOCTONIA RESISTANCE EVALUATION OF MISCELLANEOUS
SUGARBEET LINES AND HYBRIDS

Experiment R-6

J. O. Gaskill and E. G. Ruppel

Forty sugarbeet lines and hybrids were evaluated for Rhizoctonia resistance in the field in a manner similar to that described for Experiment R-4. The summarized results are presented in Table 1, and a line contrast is shown in Figure 1.

All of the FC 701 lines (entries 907-911, inclusive) were significantly superior to their source variety, GW 674-56C (entry 906), in Rhizoctonia resistance. Likewise, all of the FC 702 lines (entries 913-917) were significantly superior to their source variety, C 817 (entry 912). With one exception, there were no significant differences (a) among the FC 701 lines, or (b) among the FC 702 lines. These statements are based on both types of results shown--i.e., in the "Disease index" and the "Healthy (%)" columns in Table 1. These observations were in agreement with results obtained from Experiment R-4.

Each of the entries, 927-932, is a product resulting from pooling of lines derived from both GW 674-56C and C817. Each of the entries, 927-932, was significantly superior to GW 674-56C (entry 906) and C 817 (entry 912) in disease index and in percentage of healthy plants. Although none of the entries, 927-932, differed significantly from any of the FC 701 and FC 702 lines, they are of special interest because of the broader base from which they were derived. Further selection in these lines, for Rhizoctonia resistance, seems highly desirable.

Entries 935-940 are products of an attempt to combine resistance to leaf spot, curly top, and Rhizoctonia. Progress in this undertaking has been reported (see literature citation no. 2 in our report for Experiment R-4). All but one of the entries, 935-940, were significantly superior to the Rhizoctonia susceptible parent, FC 901 (entry 933), in disease index and percentage of healthy plants. Most of them, including entry 937, were about equal to FC 701 and FC 702. Entry 937, shown in Figure 1, is of special interest because, in addition to its Rhizoctonia resistance, it has resistance to leaf spot and curly top about equal to that of SP 5481-0 and US 41, respectively. It is a relatively vigorous line. We have no information regarding its sucrose percentage. It has been assigned the number, FC 801. We plan, tentatively, to make it available to the sugarbeet industry, through the Beet Sugar Development Foundation, in the spring of 1971.

Entries 921-926 are F₁ hybrids having a Rhizoctonia susceptible CMS line or hybrid (see entries 918-920) as the ♀ parent and a Rhizoctonia resistant line (FC 701/2 or FC 702/2) as the ♂ parent. In disease index, each F₁ was significantly superior to its susceptible parent. In percentage of healthy plants, the average for each F₁ was higher than that of the corresponding susceptible parent. In three of the six cases the differences were significant. These results were in agreement with those obtained in Experiments R-3 and R-4.

Table 1. Rhizoctonia resistance evaluation of miscellaneous lines and hybrids, Fort Collins, Colorado, 1970 (Experiment R-6); results presented as 5-plot averages ^{1/}

Entry no.	Seed no.	Description and/or source	Rhiz. ^{2/} res.sel.	Disease ^{3/} index	Healthy ^{4/} (%)
901	SP 691007-0	From misc. sources, incl. <u>B. maritima</u> ; MM	+	0.62 i j k l	57.3 abcdefgh
902	" 691252-00	do.	+	0.92 f g h i j k l	45.8 defghijkl
903	Acc. 2233	SP 5831-0; LSR-BRR, mm	-	1.30 defg	42.9 fghijkl
904	SP 691006-0	From SP 5831-0(+); mm	+	0.80 g h i j k l	46.6 defghijkl
905	" 691251-00	do.	+	0.76 g h i j k l	48.1 cdefghijkl
906	Acc. 2168	GW 674-56C; LSR commercial variety, MM	-	2.10 c	24.7 mnop
907	SP 681008-0	FC 701; from GW 674-56C; 4 cyc. Rhiz. res. sel.	+	0.88 f g h i j k l	56.0 abcdefghi
908	" 671007-0	FC 701/2; " " " " ; 5 " " " "	+	0.45 l	71.7 a
909	" 691207H0	FC 701/2; Fort Collins increase	+	0.65 i j k l	60.7 abcdef
910	Acc. 2713	" " ; Oregon "	+	0.84 f g h i j k l	53.3 bcdefghijkl
911	SP 691246-00	" 701/4; from GW 674-56C; 6 cyc. Rhiz. res. sel.	+	0.52 k l	60.2 abcdef
912	" 621220H0	C 817; Powers' deriv. from GW 359-52R; MM	-	1.55 cde	18.5 opq
913	" 681009-0	FC 702; from C 817; 4 cyc. Rhiz. res. sel.	+	0.59 i j k l	54.9 abcdefghi
914	" 671008-0	FC 702/2; " " " ; 5 " " " "	+	0.54 j k l	66.5 abc
915	" 691208H0	" " ; Fort Collins increase	+	0.73 g h i j k l	60.8 abcdef
916	Acc. 2714	" " ; Oregon "	+	0.79 g h i j k l	54.2 abcdefghij
917	SP 691247-00	" 702/4; from C 817; 6 cyc. Rhiz. res. sel.	+	0.70 h i j k l	64.1 abcd
918	" 671211H01	" 602-CMS; LSR-CTR, mm	-	1.73 cd	34.4 lmn
919	" 681151H01	SP 652016s1-CMS; LSR-CTR, mm	-	3.52 a	19.2 opq
920	" " H03	(FC 602 x SP 652016s1)-CMS; LSR-CTR, mm	-	3.25 ab	16.9 pq
921	" 691207H04	FC 602-CMS x FC 701/2		0.83 f g h i j k l	44.5 e f g h i j k l
922	" " H05	SP 652016s1-CMS x " "		1.56 cde	33.0 lmno
923	" " H07	(FC 602 x SP 652016s1)-CMS x " "		1.53 cde	35.4 klm
924	" 691208H04	FC 602-CMS x FC 702/2		1.07 e f g h i j k	44.0 e f g h i j k l
925	SP 691208H05	SP 652016s1-CMS x " "		1.39 def	36.1 jklm
926	" " H07	(FC 602 x SP 652016s1)-CMS x " "		1.11 e f g h i j	38.7 i j k l m
927	" 691001-0	FC 703; F ₂ , FC 702 x FC 701	+	0.49 l	61.4 abcdef
928	" 691249-(01)	Deriv. fr. pool of lines fr. GW 674-56C & C 817	+	0.45 l	65.5 abc
929	" " -(02)	do.	+	0.46 l	64.2 abcd
930	" " -(03)	do.	+	0.46 l	62.1 abcde
931	" " -(04)	do.	+	0.49 l	68.5 ab
932	" 691250-00	do.	+	0.61 i j k l	54.6 abcdefghi
933	" 661203H0B	FC 901; LSR-CTR, MM	-	2.77 b	10.9 q
934	" 631001-0	From GW 674-56C; 2 cyc. Rhiz. res. sel.	+	1.15 defghi	35.6 klm
935	" 691248-(01)	F ₄ , FC 901 x SP 631001-0	+	1.27 defgh	19.9 nopq
936	" " -(02)	do.	+	1.14 efghi	60.1 abcdefg
937	" " -(03)	do.	+	0.72 h i j k l	50.2 bcdefghijkl
938	" " -(04)	do.	+	0.87 f g h i j k l	41.0 h i j k l m
939	" " -(05)	do.	+	0.72 h i j k l	41.6 g h i j k l
940	" " -(06)	do.	+	0.64 i j k l	54.0 abcdefghij

^{1/} Means followed by the same letter are not significantly different, according to Duncan's multiple range test (5% level).

^{2/} Classification according to breeding history: + = product of selection for Rhizoctonia resistance; - = no selection for Rhizoctonia resistance; classification omitted for F₁ hybrids, susceptible x resistant.

^{3/} Disease index based on the scale, 0 = essentially healthy and 5 = dead.

^{4/} Percentage of population classed as essentially healthy. Bliss' transformation (to degrees) was used for summarization, analysis of variance, and Duncan's multiple range test.



Fig. 1. Comparison of Rhizoctonia resistance of two sugarbeet lines in 1-row plots (indicated by stakes), Fort Collins, Colo., Exp. R-6, 10/3/70: Left, entry 933 (FC 901); right, entry 937 (F_4 , FC 901 x SP 631001-0). (Photo. no. 207-31).

EFFECT OF SELECTION FOR RHIZOCTONIA RESISTANCE ON
THE MEANS AND VARIANCES OF ROOT YIELD AND SUCROSE

R. J. Hecker and J. O. Gaskill

Selection for resistance to Rhizoctonia root and crown rot was commenced at Fort Collins in 1956. Initial progress was somewhat discouraging because artificial disease exposure techniques were simultaneously being developed and tested, and the frequency of resistance genes in the source populations was undoubtedly low. But selection efforts were continued with rewarding results in the form of several relatively resistant lines, including FC 701 and FC 702 (1). After five cycles of mass selection for resistance we considered it useful to compare, under disease-free conditions, the means and variances of FC 701 and FC 702 with their respective source populations GW 674-56C and C 817. Specifically we used sublines FC 701/2 and FC 702/2. The number of seed producing plants in each cycle of selection involved in the development of FC 701/2 and FC 702/2 is shown in Table 1. In practically all cycles there was some death loss of plants prior to seed set. Some of these plants probably contributed pollen even though they contributed no seed to the next generation. Also in certain cases other sublines of the same basic population were flowering nearby, so there may have been a limited amount of pollen contributed by other sublines.

The four populations (FC 701/2, FC 702/2, GW 674-56C, and C 817) were grown in 1969 at the Colorado State University Agronomy Research

Center in single row plots, each bordered by a medium vigor common competitor. Twelve plants were harvested from each plot (40 reps) and individually analyzed for root weight and sucrose, for a total of 480 plants per population.

Root Yield

Population means and variances for root yield are listed in Table 2. Comparing selections with source populations, significant reductions in root weight did occur through five cycles of selection for Rhizoctonia resistance. The 7 and 24% yield reductions of FC 701/2 and FC 702/2, respectively, were not drastic considering the small number of plants in certain selection cycles (Table 1). The fewer the individuals in a cycle, the higher the probability that relatives or more closely related individuals mated in succeeding generations. Hence, there was a certain amount of inbreeding taking place in each generation. There should have been more inbreeding in FC 702/2 than in FC 701/2, since FC 702/2 had fewer individuals in the first three cycles. This was reflected in the lower mean of FC 702/2.

The possibility of a genetic linkage between resistance and low root yield cannot be ruled out, but it would appear that most of the yield reduction in FC 701/2 and FC 702/2 can be attributed to inbreeding depression.

The variances of root weight in Table 2 were total within-plot variances; as such they do not include variability due to replications. The variances of FC 701/2 and FC 702/2 confirm that a certain amount of inbreeding had occurred. At the 5% level of significance the variances of GW 674-56C and FC 701/2 were on the verge of being different. GW 674-56C and C 817 variances were not different. C 817 and FC 702/2 variances were different, as were FC 701/2 and FC 702/2. The variance of FC 702/2 was probably underestimated due to a positive relationship of means and variances. On a trial basis (not reflected in Table 2), the root weight data were transformed to \log_{10} , but this transformation "over-corrected" for the mean-variance relationship. Even with the "over-correction", the variance of FC 701/2 was significantly higher than FC 702/2. In spite of the probable underestimation of the FC 702/2 variance and the possible slight inflation of the GW 674-56C variance, the variances of untransformed data in Table 2 were considered more accurate and comparable than variances from \log_{10} data.

Sucrose

The sucrose means in Table 2 are interesting in that FC 701/2 and FC 702/2 have diverged considerably. This difference, the means being 12.1% and 13.8%, is quite large considering that there was no selection pressure for sucrose during the five cycles of selection for Rhizoctonia resistance. The sucrose differences must have resulted by chance in those cycles where only a few plants contributed to the next generation.

The sucrose variances are also interesting in that FC 701/2 had the highest variance in the test, although not significantly higher than GW 674-56C or C 817. There was a marked reduction in the variance of FC 702/2. It was significantly lower than the variances of the other three entries. The variance of FC 702/2 was lower than might have been expected due to the inbreeding during selection, while the high variance of FC 701/2 seems inexplicable except by chance alone. A negative mean and variance relationship is not likely since the regression of within-plot variances on means was not significant within any of the four entries. Previous studies have never shown a negative relationship except where extremely high and low sucrose lines were compared. So there is no reason to doubt the accuracy of the sucrose variances in Table 2.

Conclusions

The primary utilization of the FC 701 and FC 702 lines will undoubtedly be as a source of Rhizoctonia resistance. A backcrossing study is being commenced to determine the effectiveness and ease of transferring the resistance of FC 701 and FC 702 into susceptible breeding lines. But FC 701 and FC 702 may be useful as parental components in their current or somewhat modified forms, particularly since both lines have shown at least partial dominance for resistance when crossed with susceptible lines (2, previous Sugarbeet Research Reports, and other sections of this 1970 Report). Also it is possible that the combining ability of FC 701 and FC 702 could be improved. The results of our experiment lead to some general comments in this regard.

As noted previously, the root yield and variance of FC 701/2 have been reduced when compared with the source population GW 674-56C. This reduction, however, has not been drastic. Even though yield per se is not a good indicator of combining ability, the relatively high variance of FC 701/2 indicates that this line may still possess potential for combining ability improvement. At present, one would expect the yield combining ability of FC 701/2 to be less than GW 674-56C, but genotypes with higher combining ability which also carry high Rhizoctonia resistance might be isolated from FC 701/2. The relatively low sucrose of FC 701/2 is a definite disadvantage since there is normally little dominance for sucrose; also heterosis for sucrose is infrequent and of low magnitude. The one good thing about the sucrose of FC 701/2 is its high variance. This indicates that it should be possible to improve the sucrose of FC 701/2 by selection. The sucrose of FC 702/2 was quite high, which is an advantage, but at the same time its variance was low. Hence there would appear to be considerably less potential for sucrose improvement in FC 702/2 than in FC 701/2. The root yield of FC 702/2 is somewhat reduced and so is its variance. This low variance (even though, as noted previously, it may be an underestimate due to the mean-variance relationship) could be a definite disadvantage. The low variance of FC 702/2 might limit the potential for combining ability improvement. However, FC 702/2 should have some inherent advantage in combining ability since its source population, C 817, was a synthetic of 10 plants, from GW 359-52R, selected for their high general combining ability based on a progeny

performance test. Actually the C 817 used in this test was an increase of the original C 817. Plants for the increase had been selected mildly for leaf spot resistance. We would not expect this selection to have effected any root yield or sucrose change.

Actual test crosses using FC 701 and FC 702 or their sublimes as pollinators have been made, both by the Fort Collins station and by industry breeders, but agronomic test results, sufficient for generalizations, are not yet available.

Since the source populations, GW 674-56C (a former commercial variety of the Great Western Sugar Company) and C 817 (derived from GW 359-52R, which was also a former Great Western commercial variety), are multigerm, open-pollinated varieties adapted to conditions of the Colorado plains and immediate surroundings, the direct utilization of FC 701/2 and FC 702/2 may be somewhat limited; but at this time these lines and related material are probably the best sources of Rhizoctonia resistance anywhere in the sugarbeet world.

Literature Cited

- (1) Gaskill, J. O. 1968. Breeding for Rhizoctonia resistance in sugarbeet. J. Amer. Soc. Sugar Beet Technol. 15: 107-119.
- (2) Gaskill, J. O., D. L. Mumford and E. G. Ruppel. Preliminary report on breeding sugarbeet for combined resistance to leaf spot, curly top, and Rhizoctonia. J. Amer. Soc. Sugar Beet Technol. (In press).

Table 1. Number of seed producing plants in each cycle of selection for Rhizoctonia resistance.

Subline	Selection cycle and number of plants				
	1st	2nd	3rd	4th	5th
FC 701/2	7	25	3	28	24
FC 702/2	2	12	2	28	31

Table 2. Means and total within-plot variances of root yield and sucrose for Rhizoctonia resistant lines and source populations, 1969.

Population	Root weight		Sucrose	
	Mean $\frac{1}{2}$	Variance	Mean $\frac{1}{2}$	Variance
	(kg)		(%)	
GW 674-56C	1.13 a	0.3573	13.0 b	2.2101
FC 701/2	1.05 b	0.3067	12.1 c	2.3928
C 817	1.08 ab	0.3999	13.2 b	2.0656
FC 702/2	0.82 c	0.1745	13.8 a	1.1641

$\frac{1}{2}$ Means followed by the same letter are not significantly different (5% level).

SUMMARY OF COMPARISONS OF RHIZOCTONIA-LIKE ISOLATES FROM SUGARBEET

E. G. Ruppel

Isolate	Disease	Growth on PDA-YE <u>1</u> / (cm/day)	Anastomosis group <u>2</u> / 	Cultural pigment <u>3</u> /
R-1	Root rot	0.8-0.9 (0.8)	II	Reddish brown
-2	Root rot	0.8-0.9 (0.8)	II	Reddish brown
-3	Root rot	0.8-1.0 (0.9)	II	Reddish brown
-4	Root rot	0.9-1.1 (0.9)	II	Reddish brown
-5	Crown rot	1.1-1.2 (1.2)	IV	Whitish
-6	Foliar blight	1.4-1.5 (1.5)	IV	Whitish-tan
-7	Foliar blight	1.5-1.6 (1.5)	IV	Whitish-tan
-8	Root rot	0.7-0.8 (0.8)	II	Reddish brown
-9	Root rot	0.6-0.8 (0.7)	II	Reddish brown

1/ Growth rates in cm/day on PDA-YE (potato dextrose agar with 1 g yeast extract/liter) were calculated from average radial growth from 24 to 48 hr after plating; average of 13 replications. Figures indicate range of growth rates followed by mean rate in parentheses.

2/ See Parmeter, J. R., Jr., R. T. Sherwood, and W. D. Platt. 1969. Anastomosis grouping among isolates of Thanatephorus cucumeris [= Rhizoctonia solani]. Phytopathology 59:1270-1278. Representative isolates of anastomosis groups were furnished graciously by R. T. Sherwood, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Raleigh, North Carolina.

3/ After 7 days on PDA-YE.

All isolates were characterized by multinucleate hyphal cells, dolipore septa, and hyphal diameters in excess of 5 microns. Thus, it appears that the root, crown, and foliar isolates are representative of Rhizoctonia solani. However, characterization of the perfect stage is needed for positive taxonomic identification.

POTENTIAL OF RHIZOCTONIA ISOLATES TO INCITE
DAMPING OFF, FOLIAR BLIGHT, AND ROOT ROT IN SUGARBEET

E. G. Ruppel

Nine isolates of Rhizoctonia solani Kuehn from sugarbeet were compared. Isolates R-1, R-2, R-3, R-4, R-8, and R-9 were recovered from rotting roots; R-5 was isolated from a beet with crown rot symptoms; R-6 and R-7 were isolated from the foliage of blighted beets. R-7 and R-8 were obtained from beets grown in Arizona, whereas all other isolates were cultured from beets grown in widely scattered areas of eastern Colorado. R-9 (= B-6) has been used for creating epidemics of root rot in breeding nurseries at Fort Collins for several years.

Damping off.--Surface-sterilized seed of sugarbeet lines GW 674-56C (highly susceptible to Rhizoctonia) and FC 701/2 (resistant; derived from GW 674-56C) were covered with aliquots of 3-week-old sand-oatmeal cultures of the isolates at planting. A randomized block design with six replications was used. Percentage damping off, based on survival of non-inoculated control seedlings, was recorded 21 days after planting (Table 1).

An analysis of variance indicated significant differences among isolates and between lines. Duncan's multiple range test showed that R-1 and R-9 induced significantly less damping off than R-3, -5, -7, and -8. Isolates R-5 and R-7 tended to incite more damping off than the other isolates. More damping off occurred in line GW 674-56C than in FC 701/2. There was no significant isolates x lines interaction.

Foliar blight.--Aqueous mycelial suspensions, prepared by comminuting in a blender mycelial mats from broth cultures, were atomized on the foliage of 2-month-old plants of lines GW 674-56C and FC 701/2. The inoculated plants were held in a mist chamber at 100% relative humidity under constant light at 25-30 C for 48 hr. A randomized block design was used with five replications.

Within 48 hr foliar lesions appeared in the leaves of plants inoculated with R-5, R-6, and R-7. One lesion developed on a plant inoculated with R-1 and on one inoculated with R-9. Disease ratings (Table 1) of 0 to 3 were based on ascending quantity of lesions per leaf.

An analysis of variance of disease ratings obtained from plants inoculated with R-5, R-6, and R-7 indicated highly significant differences among isolates. Duncan's multiple range test revealed that differences between R-6 and R-7 were not significant, but both induced significantly more foliar lesions than R-5. There were no significant differences between lines, and the isolates x lines interaction also was not significant.

Root rot.--4-month-old plants of GW 674-56C and FC 701/2, grown individually in 6-inch pots of sterilized soil, were inoculated with

3-week-old sand-oatmeal cultures of the isolates. Half the plants were inoculated by placing 3 cc of inoculum in the crown, whereas the other half were inoculated by placing 3 cc of inoculum about 2.5 cm from the root and 1.5 cm below the soil surface. All crown-inoculated plants were atomized with water 3 times daily for 5 days to prevent excessive drying of inoculum. Suitable non-inoculated controls also were included. A randomized block design with three replications was used for each inoculation technique. After 60 days, each root was washed free of soil and assessed a disease rating of 0 to 5 in ascending order of severity.

Separate analyses of variance performed on the disease ratings from both inoculation methods indicated highly significant differences among isolates and between lines. The isolates x lines interactions also were significant. Bartlett's test for homogeneity of error variances of the two analyses showed that the variances were homogeneous. Thus, a combined analysis was performed which disregarded inoculation technique. Again, differences among isolates (Table 1) and between lines were highly significant. The isolates x lines interaction also was significant; however, when another analysis was performed which excluded the crown and foliar isolates (R-5, R-6, and R-7) the isolates x lines interaction was not significant. Root rot was more severe in GW 674-56C than in FC 701/2 regardless of root isolate.

Discussion

Major differences were found between root isolates and the crown-foliar isolates. The latter incited severe foliar blight but very little root rot. The crown isolate and one foliar isolate (R-7) also tended to incite more damping off than the other isolates. Conversely, root rot isolates tended to incite somewhat less damping off, little, if any, leaf blight, and severe root rot. Growth and cultural appearances of the root isolates also differed appreciably from the crown and foliar isolates (Sugarbeet Research, 1969 Report, p. D14-D17).

Differences among root isolates are considered minor, consisting primarily of variation in virulence. Indeed, the nonsignificant isolates x lines interactions in the damping off experiment and in the root rot experiment (when the crown and foliar isolates were excluded) indicate that the relative behavior of the root isolates was similar in the susceptible and resistant lines.

The highly significant differences between lines in the damping off and root rot tests indicate that such tests may be useful to evaluate breeding lines in the greenhouse.

Table 1. Damping off, foliar blight, and root rot of sugarbeet incited by isolates of Rhizoctonia solani^{1/}.

Isolate		Damping off ^{2/} (%)	Disease rating	
No.	Source		Foliar blight ^{3/}	Root rot ^{4/}
R-1	Root	76.3 c	0.1	3.0 a
R-2	Root	78.3 abc	0	1.9 b
R-3	Root	81.3 ab	0	2.7 ab
R-4	Root	79.4 abc	0	2.1 b
R-5	Crown	89.1 a	0.9 b	0.3 c
R-6	Foliage	79.4 abc	2.8 a	0.3 c
R-7	Foliage	87.5 ab	2.7 a	0.4 c
R-8	Root	82.4 ab	0	2.9 a
R-9	Root	65.6 c	0.1	2.3 ab

^{1/} Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

^{2/} Percentage of healthy non-inoculated control seedlings; means of 5 replications.

^{3/} 0 to 3 in ascending order of severity; means of 5 replications. Only isolates 5, 6, and 7 included in analysis.

^{4/} 0 to 5 in ascending order of severity; means of 6 replications.

LONGEVITY OF RHIZOCTONIA ISOLATES UNDER COLD STORAGE

E. G. Ruppel and J. O. Gaskill

Isolates B-6 and 396-4 of Rhizoctonia solani, obtained from partially rotted sugarbeets, were grown on moist, whole barley grain in test tubes at room temperature from July 12 to August 17, 1962. The cultures then were either transferred to a deep-freeze at about -18 C or placed in the refrigerator at 3-4 C. Those cultures placed in the refrigerator were transferred to the deep-freeze on October 12, 1962.

In November, 1969, the cultures were removed from the deep-freeze and aliquots of each were plated on potato-dextrose agar. All cultures grew profusely with no evidence of loss in viability.

Tests on 4-month-old sugarbeets ('S 301-H') in the greenhouse indicated that both isolates were highly pathogenic after 7 years in cold storage.

DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING MATERIAL AND VARIETIES WITH RESISTANCE TO BOTH LEAF SPOT AND CURLY TOP, 1970

J. O. Gaskill, E. G. Ruppel, and G. A. Smith

In this so-called "LSR-CTR project", major emphasis was given in 1970 to the continuing program of development and evaluation of LSR-CTR, monogerm, type-0 lines and their male-sterile equivalents. This program consists of four principal steps: (1) initial development of type-0 lines and their male-sterile equivalents; (2) preliminary, direct evaluation for disease resistance and other observational characters; (3) evaluation for combining ability and disease resistance by means of top-cross tests; and (4) cooperative agronomic and disease resistance tests, conducted by Federal, State, and sugar company research personnel in various parts of the United States. The development and evaluation of LSR-CTR, non-type-0 lines, suitable for use as pollinators, also is an important part of the over-all LSR-CTR project. Steps (1), (2), (3), and (4), with some modifications, are applicable to the development and evaluation of pollinators.

Participation by Dr. D. L. Mumford, of the Sugarbeet Investigations Station at Logan, Utah, is invaluable in making curly top resistance determinations in connection with steps (2), (3), and (4), described above. Dr. Mumford also assists by selecting individual plants for curly top resistance, and Dr. J. C. Theurer, of the Logan Station, assists by making reproductions of some of the selected material. Participation by other investigators in the evaluation program is acknowledged in connection with the respective reports which follow.

Field work under leaf spot conditions on the Disease Farm (Warren Tract) at Fort Collins in 1970 included the following items, among others: (1) an agronomic test of LSR-CTR varieties; (2) observational tests of numerous monogerm type-0 lines, pollinator lines, Rhizoctonia resistant lines, top-cross hybrids, and miscellaneous material; (3) a replicated test of leaf spot resistant and susceptible lines, comprising a part of a study of the relationship between phytoalexins and leaf spot resistance (cooperative with Drs. D. D. Maag and Gestur Johnson of the Chemistry Department, CSU), and pertaining also to a study on quality in which Dr. R. J. Hecker and Mrs. G. W. Maag, of the Sugarbeet Investigations staff, are the principal investigators; (4) evaluation of leaf spot resistance of material furnished by four sugar companies (total of 332 plots); (5) evaluation and selection of plants in two segregating populations, in furtherance of a study on the inheritance of leaf spot resistance; and (6) selection of plants in segregating material furnished by Drs. Helen Savitsky and E. D. Whitney, Sugarbeet Investigations, Salinas, California, in an attempt to utilize the leaf spot resistance occurring in Beta procumbens. Agronomic tests of LSR-CTR varieties and top-cross hybrids, conducted on the CSU Agronomy Research Center in cooperation with Dr. R. J. Hecker of the Sugarbeet Investigations staff, served as valuable supplements to the tests on the Disease Farm.

Mother beet selection, steckling production, reproduction, selfing, and hybridization were included in the 1970 research program of the LSR-CTR project, involving both field and greenhouse work.

Most of the data obtained from the 1970 tests will be used for future guidance in this project. Results obtained from only two phases of this project are presented in this report: (1) Development of LSR-CTR, Monogerm, Type-0 Populations; and (2) Cooperative Tests of LSR-CTR Varieties.

Development of LSR-CTR, Monogerm, Type-0 Populations

Progress in breeding LSR-CTR, monogerm, type-0 lines has been reported in several issues of Sugarbeet Research Report (e.g. 1963, pp. 187-188; 1964, pp. 164-165; 1965, pp. 192-196) and in the Journal of the American Society of Sugar Beet Technologists [14(6): 518-537, 1967]. All such lines were derived from populations which had been synthesized specifically for this project and which were segregating for the type-0 genotype. The frequency of occurrence of these genotypes was relatively low.

In order to improve breeding efficiency, the synthesis of LSR-CTR, monogerm, type-0 populations, to serve as sources for selection, was begun in 1966 with the crossing of FC 601 and SP 632028s1. These LSR-CTR, monogerm, type-0 lines were derived from SP 611101-0, a product of a backcrossing and selection program described on page 187 of Sugarbeet Research, 1963 Report. They are described in some detail on pages 532-535 of the Journal article cited above. These lines are self fertile, but both are segregating for Mendelian male sterility (aa). This character was used to enforce hybridization to produce the F_1 , FC 601 x SP 632028s1. The F_2 (SP 681205H00) was produced in 1968 by pooling F_1 mother beets that had been selected under leaf spot conditions in 1967.

Approximately 1/10 acre near Salem, Oregon, was planted with the seed lot, SP 681205H00, late in the summer of 1968. The plants were field overwintered and thinned to a spacing of about 2 ft. in the row, leaving a population of approximately 1,000 individuals. Roguing was done at flowering time (June, 1969) on the basis of several plant characters. Seed produced by the remaining 158 plants (123 male fertile and 35 male sterile) was harvested separately for the respective plants and sent to Fort Collins for processing and evaluation. All work involved in the production of this seed crop, except roguing, was performed by the staff of the West Coast Beet Seed Company under the direction of Mr. Sam C. Campbell, Manager. The roguing was performed by Drs. G. A. Smith and G. J. Hogaboam of the Fort Collins, Colorado, and East Lansing, Michigan, Sugarbeet Investigations stations, respectively.

In studying the 158 F_3 seed lots at Fort Collins during the winter of 1969-70, special attention was given to the number of seed units per locule. This was done by means of a method, devised at Fort Collins several years ago, involving partial germination and counting of seed units per locule.

In 1970, 59 of the seemingly more desirable F_3 lines were evaluated for Cercospora resistance in the leaf spot nursery at Fort Collins (Exp. 4A). These lines also were evaluated for curly top resistance at Logan, Utah, by Dr. D. L. Mumford, Sugarbeet Investigations. The latter study involved determinations in both field and greenhouse for each line.

Of the 59 F_3 lines evaluated, (a) 50 were equal to or lower (i.e. better) than SP 5822-0 in average leaf spot grade, (b) 42 were equal to or lower (i.e. better) than US 41 in average curly top grade, and (c) 34 were equal to or lower than both of these standard varieties in the respective disease grades. The results for the more outstanding lines in category (c) are presented in Table 1 together with results for 5 standard or check varieties. These data probably are self-explanatory with the exception of the curly top grade (106) shown for SP 5481-0 in the greenhouse. This grade (a percent-of-check value) was based on the following actual grades and computations: US 41 = 8.1, SP 5481-0 = 8.6 (0 = healthy and 9 = dead), and $(8.6/8.1) \times 100 = 106$. The evaluation procedure included the use of an extremely virulent isolate of the curly top virus (Logan no. 66-10) and inoculation of plants while in the cotyledon stage. These factors resulted in such a severe disease exposure that US 41, the resistant check, was graded 8.1 (actual). With this grade for the resistant check, and since the highest possible actual grade was 9.0, the highest percent-of-check value obtainable for the most highly susceptible lines in this test = $(9.0/8.1) \times 100 = 111$. Consequently, under the conditions of this test, percent-of-check values greater than 100 must be considered relatively unreliable. SP 5481-0 has been included as a curly top susceptible check in numerous greenhouse tests at Logan, and its reaction to curly top has been clearly established. For example, in a test in 1968, the average grades for SP 5481-0 and US 41 were 8.0 and 6.0, respectively, and the percent-of-US 41 value for SP 5481-0 was 133. This is typical.

As mentioned above, the original parents of the F_3 lines listed in Table 1 are type-0. Consequently, it seemed probable that the F_3 lines would be type-0. Evidence supporting this assumption was obtained in the winter of 1968-69 when 91 seedlings of the CMS equivalent of the F_2 generation were classified for anther type. Without exception these plants were male sterile.

As indicated on page 187 of Sugarbeet Research, 1963 Report, the backcrossing program (carried to the B_2) which led to the development of SP 611101-0 and ultimately to FC 601, SP 632028s1, and the F_3 lines listed in Table 1, involved the following source material: (a) US 201 as the nonrecurrent parent and the source of leaf spot resistance; and (b) CTR lines (US 22/3, US 22/4, SL 202, and SLC 122-0) serving as the recurrent parental type. Each of these CTR lines is quite susceptible to leaf spot. It is gratifying to note that many of the F_3 lines evaluated in this study are approximately equal to or better than SP 5822-0 in leaf spot resistance and also about equal to or better than US 41 in curly top resistance. Extrapolating from these results, it can be

Table 1. Leaf spot and curly top resistance of superior LSR-CTR, monogerm, type-0, F₃ lines, evaluated at Fort Collins, Colorado, and Logan, Utah, 1970.

Entry :	Variety ^{1/}	: Leaf spot :	Curly top grade ^{3/}		
no. :	or line	: grade ^{2/} :	G.H.	: Field	: Aver.
<u>I. F₃ lines (LSR-CTR, mm, type-0):^{4/}</u>					
403	SP 691099-11A	1.5	99	86	92.5
410	" " -26A	2.3	90	78	84.0
411	" " -27A	2.3	100	86	93.0
413	" " -33A	2.3	95	95	95.0
425	" " -70A	1.5	91	86	88.5
426	" " -71A	2.3	94	95	94.5
427	" " -76A	2.0	96	78	87.0
430	" " -82A	1.0	86	95	90.5
432	" " -84A	2.0	93	95	94.0
434	" " -91A	2.0	94	95	94.5
435	" " -95A	1.0	93	95	94.0
436	" " -98A	2.0	89	95	92.0
441	" " -107A	2.3	89	95	92.0
443	" " -112A	2.0	86	86	86.0
444	" " -115A	1.0	89	103	96.0
447	" " -132B	2.0	89	86	87.5
453	" " -142B	2.3	96	95	95.5
454	" " -148B	2.3	94	95	94.5
455	" " -149B	2.3	96	95	95.5
456	" " -152B	2.3	97	95	96.0
<u>II. Checks:</u>					
460	SP 5822-0	2.5			
461	SP 5481-0	3.3	106	138	122.0
462	Synthetic Check	6.0			
	US 33			116	
	US 41		100	100	100.0

^{1/} Numbers ending with letters A and B represent male-fertile and male-sterile (aa) seed-bearing plants, respectively.

^{2/} Leaf spot grades (Fort Collins Exp. 4A) based on the scale, 0 = healthy and 10 = complete defoliation; 2 replications (plot size, 2 rows x 12').

^{3/} Curly top grades, recorded at Logan, are shown as percent of US 41. Grades lower than 100 indicate higher resistance than US 41. There were 5 replications in the greenhouse (normally 5 pots, with 4 plants per pot, for each entry). In the field there were 2 replications, except for US 33 and US 41 which occurred in 6 plots, each (plot size, 1 row x 16').

^{4/} A total of 59 F₃ lines were evaluated. Of this number, only those lines having an average leaf spot grade of 2.3 or lower and an average curly top grade of 96.0 or lower are included in this table.

concluded with reasonable certainty that several of the F_3 lines are at least as high as US 201, the nonrecurrent parent, in leaf spot resistance, and about equal to or better than the recurrent parental type, as a class, in curly top resistance.

In view of these results, we believe it is safe to conclude that, with further use of the methods employed thus far, involving modern, highly resistant, CTR lines as future representatives of the recurrent parental type, substantial additional progress can be made. Specifically, we plan to begin by crossing, this spring, a number of the above F_3 lines with Logan, monogerm, type-0 lines: (a) L-36 (high curly top resistance and good general combining ability) and (b) L-35 (very high curly top resistance); and follow this step with LSR selection and other steps similar to those employed in the development of the F_3 lines described above, insofar as appropriate. Beets selected in the field in 1970 are to be used for making the crosses in the greenhouse in the spring of 1971. The program subsequently will be broadened by inclusion of bolting resistant lines with high curly top resistance from Salinas. Rhizoctonia resistance already has been incorporated in this program by crossing FC 701 and FC 702 with material related to the F_3 's discussed in this report.

The work discussed in the preceding paragraph represents long-range goals. In the immediate future, the F_3 lines described above are to be evaluated for various characters in addition to retesting for leaf spot and curly top resistance. Special emphasis will be given to combining ability. The type-0 character will be checked. Selections will be made from these lines on the assumption that some of them probably are segregating for various important characters. These lines also are to be crossed with other LSR-CTR, monogerm, type-0 lines with the objective of creating populations of this type, having a broader base, from which selections for high combining ability and other characters may be made.

Cooperative Tests of LSR-CTR Varieties

The varieties described in Table 2 were evaluated by federal, state, and sugar company research personnel in several states in 1970. Because of computer problems, the results of several tests are not available at this time. Summaries of available agronomic data are presented in Tables 3, 4, 5, and 6. Available disease-resistance results are summarized in Table 7. Reports for the individual agronomic tests are presented in Tables 8-15, inclusive. The results obtained in a test at Willcox, Arizona (Tables 14 and 15) are not included in the summary tables because of the inadvertent omission of Thimet and pre-plant fertilizer on a part of that test.

Although Tables 14 and 15 are not strictly comparable, they indicate striking beneficial effects of the Thimet and pre-plant fertilizer application. These effects are attributed largely to the partial control of curly top by Thimet. In the following discussion, the results obtained at Willcox are disregarded.

As was to be expected, the CTR check (entry 10, US H9B) produced high sucrose yields under non-leaf spot conditions (tests A, C, and D), especially in California, and low sucrose yields under severe leaf spot conditions (tests B and E) (Table 3). The low sucrose yield of US H9B in tests B and E was in keeping with its leaf spot susceptibility as shown in Table 7. Conversely, the LSR check (entry 9, FC 506 x SP 6322-0), with high leaf spot resistance, was somewhat below the standard variety (entry 1, US H20) in average sucrose yield under non-leaf spot conditions and much above the standard variety in average sucrose yield where leaf spot was severe. The outstanding performance of that hybrid at Beltsville is of special interest and is in line with results of tests at Fremont and Old Fort, Ohio, conducted by the Northern Ohio Sugar Company in 1970 (see other reports).

Except for entries 4, 6, and 9, the average sucrose yield for the respective entries, 2 through 10, in tests A, C, and D was at least 10 percent above that of US H20 (entry 1). Entry 9 was discussed above. The female parent of entries 4 and 6 is (FC 602 x SP 652016sl). In this connection it should be noted that entry 8, with the same female parent, had a high average sucrose yield in tests A, C, and D. The contrasting performance of entry 8 vs. entries 4 and 6 may be attributable to the fact that the male parents of entries 4 and 6 are rather closely related to the female parent and, on the other hand, the male and female parents of entry 8 are considered "unrelated". An item of special importance regarding entry 8 is the fact that it apparently derived substantial Rhizoctonia resistance from the two lines that jointly served as its male parent. Specifically, as shown in Table 7, entry 8 was significantly superior to all others in Rhizoctonia resistance.

With further reference to average sucrose yield under non-leaf spot conditions (Table 3, tests A, C, and D), all but one of the hybrids having FC 506 as the female parent were high in sucrose yield. The exception, entry 9, was discussed above.

In considering sucrose yield under leaf spot conditions at Fort Collins and Beltsville, it should be recognized that environmental conditions are quite different at the two locations. Aside from intangible differences, it is known that Aphanomyces is a potential factor at Beltsville and not at Fort Collins. Although its effects were not apparent in the 1970 Beltsville test, it is not unlikely that it caused some retardation of growth of hybrids which had no background of Aphanomyces resistance breeding. Of entries 1 through 10, numbers 1 and 9 are the only ones having any background of Aphanomyces resistance breeding. Consequently, it is not surprising that entries 1 and 9 were among the top 3 in sucrose yield at Beltsville. It is surprising, however, to note that entry 7 (FC 506 x McF. 413) was: (1) high in sucrose yield both at Fort Collins and Beltsville (averaging 110.5 percent of standard); and (2) highest in average sucrose yield, among entries 1 through 10, in tests A, C, and D, where leaf spot was not a factor (averaging 113.7 percent of standard).

In general, sucrose percentages for entries 2 through 9 were substantially higher than for the standard variety, US H20 (entry 1). This trend, though more pronounced under leaf spot conditions, was quite strong where leaf spot was not a factor (see averages for tests A, C, and D in Table 5). Four percent-of-standard averages of special interest, appearing in the latter column, are those representing hybrids of FC 506--i.e. entries 2, 5, 7, and 9. Those averages are 108.3, 108.0, 106.3, and 103.7, respectively. The comparable percent-of-standard average for entry 10 (US H9B) is 102.0. The low sucrose percentage of entry 10 under leaf spot exposure was to be expected.

Purity averages for entries 1 through 10 differed relatively little (Table 6). Entry 10 (US H9B) was lowest, due, in part to its especially low purity under the severe leaf spot exposure at Beltsville. Percent-of-standard averages for entries 2 through 9 ranged from 100.0 to 101.3.

Curly top was not a factor in any of the agronomic tests summarized in Tables 3 through 6. A summary of curly top grades for three observational tests, as presented in Table 7, indicates a rather narrow range in resistance among entries 1 through 10. This is somewhat misleading, however, due to the extreme severity of curly top exposure in both of the tests at Logan. The LSR check (entry 9), which also served as a curly top susceptible (CTS) check, is known to be highly susceptible to curly top. The substantial curly top resistance of the CTR check (entry 10, US H9B) is well known. However, the average curly top grades for these two entries appear in Table 7 as 6.5 and 5.5, respectively. Thus it should be recognized that, under the conditions of these tests, small mean differences in curly top grades apparently represent substantial differences in actual resistance. On the basis of the 3-test averages, it appears that all of the entries, 1 through 8, have some curly top resistance, relative to the CTS check (entry 9), and that five of them are about equal to US H9B in resistance.

A relatively wide range in leaf spot resistance, among entries 1 through 10, is shown in Table 7. As expected, the LSR check (entry 9) and the CTR check (entry 10) appeared to be the most resistant and the most susceptible, respectively. The standard variety (entry 1, US H20) ranked next to entry 10 in susceptibility. All of the entries, 2 through 9, appeared to be substantially more resistant than the standard variety.

Table 2. Description of material in cooperative evaluation tests of LSR-CTR varieties, 1970^{1/}

Entry no.	Ft. Collins Seed no.	Description ^{2/}
1	Acc. 2707	US H20 [SL(129 x 133) x SP 6322-0]; monogerm; LSR-CTR-BRR; furnished by F & M.
2	SP 691202H02	FC 506 x FC 901; monogerm; LSR-CTR.
3	SP 671203H08	FC(504 x 502/2) x FC 901; monogerm; LSR-CTR.
4	SP 691202H07	(FC 602 x SP 652016s1) x FC 901; monogerm; LSR-CTR.
5	SP 691203H02	FC 506 x FC 902; monogerm; LSR-CTR.
6	SP 691203H07	(FC 602 x SP 652016s1) x FC 902; monogerm; LSR-CTR.
7	SP 691206H02	FC 506 x McF. 413; monogerm; LSR-CTR; probably with some yellows resistance.
8	SP 691900H07	(FC 602 x SP 652016s1) x (FC 701/2 and FC 702/2); monogerm; LSR-CTR, probably with some Rhizoctonia resistance.
9	SP 691201H02	FC 506 x SP 6322-0; monogerm; <u>LSR check</u> ; probably some BRR.
10	Acc. 2706	US H9B; monogerm; <u>CTR check</u> ; also resistant to yellows and bolting; furnished by J.S. McFarlane.

^{1/} In addition to the varieties listed in this table, one or more "local checks", furnished by cooperators, were included in the tests as indicated in the respective tables of results.

^{2/} The following symbols pertain to loose, initial classification for disease resistance: **BRR** = black root resistant (i.e. resistant to Aphanomyces-type black root); **CTR** = curly top resistant; **LSR** = resistant to Cercospora leaf spot.

Table 3. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1970; as percent of the standard variety, US H20.

Gross Sucrose Yield									
Seed no. and/or variety	Entry No.	Test and Locality						Aver. (omit F)	
		A	B	C	D	E	F	Negl. LS	Severe LS
		Spreck. Calif.	Ft. Colo.	Ft. Colo.	Long. Colo.	Belts. Md.	Farm. N.M.	(A,C,D)	(B,E)
No. of replications		8	6	8	6	3	6		
Leaf spot ^{1/}		0	3	0	0	3	0		
Reliability ^{2/}		ex	vg	vs	g	5	g		
Acc. 2707 (US H20)	1	100	100	100*	100*	100	100	100.0	100.0
SP 691202H02	2	122	110	108*	108*	83	94	112.7	96.5
SP 671203H08	3	123	105	112*	100*	88		111.7	96.5
SP 691202H07	4	117	100	104*	85*	70		102.0	85.0
SP 691203H02	5	108	111	117*	106*	97	94	110.3	104.0
SP 691203H07	6	107	94	97*	95*	81		99.7	87.5
SP 691206H02	7	124	110	115*	102*	111	91	113.7	110.5
SP 691900H07	8	110	108	121*	102*	97		111.0	102.5
SP 691201H02	9	101	105	102*	85*	132	78	96.0	118.5
Acc. 2706 (US H9B)	10	128	79	113*	98*	70	99	113.0	74.5
Local check a ^{3/}		129	103	123*	110*	114	100		
Local check b ^{3/}		114	110	136*	92*	108			
LSD (.05) ^{4/}		11	10	15*	14*	14	13		

^{1/} Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

^{2/} Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

^{3/} Local checks (test symbols in parentheses): (A) a = S-101H12, b = S-501H2; (B) and (C) a = GW 674-56C, b = GW 19-68R; (D) a = 68MSH151, b = GW 761; (E) a = SP 67550-02 x SP 6322-0, b = SP 6922-0; (F) a = HH-7.

^{4/} LSD (.05) expressed as percent of sucrose yield of the standard variety (entry no. 1).

* Recoverable sucrose

Table 4. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1970; as percent of the standard variety, US H20.

Beet Yield

Seed no. and/or variety	Entry No.	Test and Locality							Aver. (omit F)	
		A		B	C	D	E	F	Negl. LS (A,C,D)	Severe LS (B,E)
		Spreck. Calif.	Ft.Col. Colo.	Ft.Col. Colo.	Long. Colo.	Belts. Md.	Farm. N.M.			
No. of replications		8	6	8	6	3	6			
Leaf Spot ^{1/}		0	3	0	0	3	0			
Reliability ^{2/}		ex	vg	vs	g	s	g			
Acc. 2707 (US H20)	1	100	100	100	100	100	100	100	100.0	100.0
SP 691202H02	2	105	102	100	102	80	92	92	102.3	91.0
SP 671203H08	3	105	97	105	96	83			102.0	90.0
SP 691202H07	4	107	92	96	90	68			97.7	80.0
SP 691203H02	5	96	96	103	102	88	91	91	100.3	92.0
SP 691203H07	6	96	85	90	99	76			95.0	80.5
SP 691206H02	7	109	99	104	100	99	90	90	104.3	99.0
SP 691900H07	8	99	96	103	98	90			101.7	93.0
SP 691201H02	9	91	96	94	87	116	79	79	90.7	106.0
Acc. 2706 (US H9B)	10	118	81	108	105	74	100	100	110.3	77.5
Local check a ^{3/}		112	91	107	99	93	99	99		
Local check b ^{3/}		99	97	119	89	97				
LSD (.05) ^{4/}		10	8	9	10	15	--	--		

^{1/} Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

^{2/} Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

^{3/} Local checks (test symbols in parentheses): (A) a = S-101H12, b = S-501H2; (B) and (C) a = GW 674-56C, b = GW 19-68R; (D) a = 68MSH151, b = GW 761; (E) a = SP 67550-02 x SP 6322-0, b = SP 6922-0; (F) a = HH-7.

^{4/} LSD (.05) expressed as percent of beet yield of the standard variety (entry no. 1).

Table 5. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1970; as percent of the standard variety, US H20.

Seed no. and/or variety	Entry No.	Sucrose Percentage							Aver. (omit F)	
		Test and Locality							Negl. LS (A,C,D)	Severe LS (B,E)
		A Spreck. Calif.	B Ft.Col. Colo.	C Ft.Col. Colo.	D Long. Colo.	E Belts. Md.	F Farm. N.M.			
No. of replications		8	6	8	6	3	6			
Leaf spot ^{1/}		0	3	0	0	3	0			
Reliability ^{2/}		ex	vg	vs	g	s	g			
Acc. 2707 (US H20)	1	100	100	100	100	100	100	100.0	100.0	
SP 691202H02	2	115	108	104	106	105	102	108.3	106.5	
SP 671203H08	3	115	110	102	103	106		106.7	108.0	
SP 691202H07	4	109	109	103	94	104		102.0	106.5	
SP 691203H02	5	112	116	107	105	111	103	108.0	113.5	
SP 691203H07	6	110	111	101	96	107		102.3	109.0	
SP 691206H02	7	113	112	105	101	113	101	106.3	112.5	
SP 691900H07	8	111	113	107	102	107		106.7	110.0	
SP 691201H02	9	110	109	103	98	114	98	103.7	111.5	
Acc. 2706 (US H9B)	10	108	98	102	96	94	100	102.0	96.0	
Local check a ^{3/}		114	114	110	110	123	101			
Local check b ^{3/}		115	114	111	106	112				
LSD (.05) ^{4/}		4	5	4	6	11	--			

^{1/} Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

^{2/} Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

^{3/} Local checks (test symbols in parentheses): (A) a = S-101H12, b = S-501H2; (B) and (C) a = GW 674-56C, b = GW 19-68R; (D) a = 68MSH151, b = GW 761; (E) a = SP 67550-02 x SP 6322-0, b = SP 6922-0; (F) a = HH-7.

^{4/} LSD (.05) expressed as percent of sucrose percentage of the standard variety (entry no. 1).

Table 6. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1970; as percent of the standard variety, US H20.

Seed no. and/or variety	Entry no.	Purity					Aver.
		Test and Locality					
		A	C	D	E		
		Spreck. Calif.	Ft. Col. Colo.	Long. Colo.	Belts. Md.		
No. of replications		8	8	6	3		
Leaf spot ^{1/}		0	0	0	3		
Reliability ^{2/}		ex	vs	g	s		
Type of pur. analyses		appar.	t.j.	t.j.	appar.		
Acc. 2707 (US H20)	1	100.0	100.0	100.0	100.0		100.0
SP 691202H02	2	102.3	100.1	100.1	99.2		100.4
SP 671203H08	3	102.1	100.1	100.5	99.3		100.5
SP 691202H07	4	100.4	100.4	100.1	99.4		100.1
SP 691203H02	5	102.1	101.2	100.2	101.6		101.3
SP 691203H07	6	101.8	101.6	100.4	100.0		101.0
SP 691206H02	7	101.4	100.4	100.4	101.8		101.0
SP 691900H07	8	98.6	100.3	100.6	100.5		100.0
SP 691201H02	9	100.8	100.6	99.7	101.5		100.7
Acc. 2706 (US H9B)	10	100.1	99.5	99.2	97.9		99.2
Local check a ^{3/}		102.5	100.2	100.1	102.1		
Local check b ^{3/}		100.1	100.0	99.2	100.9		
LSD (.05) ^{4/}		2.0	1.0	1.0	2.8		

^{1/} Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

^{2/} Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

^{3/} Local checks (test symbols in parentheses): (A) a = S-101H12, b = S-501H2; (C) a = GW 674-56C, b = GWH 19-68R; (D) a = 68MSH151, b = GW 761; (E) a = SP 67550-02 x SP 6322-0, b = SP 6922-0.

^{4/} LSD (.05) expressed as percent of purity of the standard variety (entry no. 1).

Table 7. Summary of available disease resistance comparisons, cooperative tests of LSR-CTR varieties, 1970; disease exposure intensified artificially in each test except in the Central Calif. curly top nursery.

Seed no. and/or variety	Entry no.	1/ Leaf spot grades—		2/ Curly top grades—			3/ Rhizoctonia (Ft.Col., Colo)	
		No. of replications	Ft.Col. Belts. Colo. Md.	Logan, Utah Field G.H.	Centr. Cal.	Aver.	Disease index ^{4/}	Healthy (%) ^{5/}
		Conducted by ^{6/}	6 3 2	2 5 3	2 4		6 1	6 1
Acc. 2707 (US H20)	1		5.2	6.5	2.0	5.4	1.59 de	32.60 bc
SP 691202H02	2		3.3	6.0	3.5	5.9	1.82 bcde	32.67 bc
SP 671203H08	3		3.6	6.5	3.5	5.9	2.41 ab	19.15 c
SP 691202H07	4		3.8	6.0	2.5	5.0	2.17 abcd	30.47 bc
SP 691203H02	5		2.5	6.5	3.0	5.6	1.73 cde	26.47 bc
SP 691203H07	6		3.3	6.0	2.5	5.4	2.36 abc	27.67 bc
SP 691206H02	7		3.6	6.5	3.0	5.9	1.80 bcde	29.13 bc
SP 691900H07	8		3.7	6.5	3.0	5.5	0.86 f	65.65 a
SP 691201H02	9		2.1	7.5	4.0	6.5	1.52 e	37.42 b
Acc. 2706 (US H9B)	10		6.3	6.0	3.0	5.5	1.57 de	38.92 b
GW 674-56C			4.8	8.0			1.97 bcde	31.45 bc
GMH 19-68R			5.7	8.0			1.96 bcde	27.30 bc
FC(504 x 502/2) x FC 904			2.8	6.0	8.4		1.62 de	37.28 b
(FC 602 x SP 652016s1) x FC 904			3.6	6.0	6.5		2.67 a	24.05 bc
SP 67550-02 x SP 6322-0		3.3						
SP 6922-0		3.3						
US 41				6.5	6.7			
US 33				7.0				
H69543								
S-501H2								
LSD (.05)			0.6	0.8				

1/ 0 = healthy; 10 = complete defoliation.

2/ At Logan, 0 = healthy, and 9 = dead; in central California test, 0 = healthy, and 5 = severe symptoms.

3/ Exp. R-5; means followed by the same letter are not significantly different, according to Duncan's multiple range test (5% level); results obtained by rating each beet at harvest.

4/ 0 = essentially healthy; 5 = dead.

5/ Percentage of population classed as essentially healthy.

6/ 1 = USDA (J.O. Gaskill, L.G. Kuppel, L.W. Lawson); 2 = USDA (L.E. Coe); 3 = USDA (D.L. Mumford); 4 = Spreckels Sugar Div. (J.D. Schulke).

Table 8 . Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Plant Breeding Farm - Spreckels, California

Seed number or variety	Entry no.	Acre yield		: Sucrose	: Plants per 100'	: Apparent purity	: Bolting %
		Gross : sucrose	Beets				
		Lbs.	Tons	%	No.		
Acc. 2707	1	8078	31.1	13.1	115	83.9	14.4
SP 691202HO2	2	9820	32.6	15.1	108	85.8	3.9
SP 671203HO8	3	9898	32.8	15.1	116	85.7	3.6
SP 691202HO7	4	9444	33.3	14.3	100	84.2	1.0
SP 691203HO2	5	8732	29.8	14.7	112	85.7	2.6
SP 691203HO7	6	8618	30.0	14.4	106	85.4	1.2
SP 691206HO2	7	10024	33.9	14.8	110	85.1	0.1
SP 691900HO7	8	8874	30.8	14.5	111	82.7	0
SP 691201HO2	9	8168	28.4	14.4	122	84.6	0.5
Acc. 2706	10	10342	36.7	14.1	113	84.0	0
S-101H12	11	10384	34.8	14.9	109	86.0	0
S-501H2	12	9230	30.8	15.0	104	84.0	0
General mean		9352	32.6	14.4	109	84.8	1.8
CV (%)		3.44	3.41	1.22	4.10	0.71	---
LSD (.05)		902	3.11	0.5	13.	1.7	---

Conducted by: J. D. Schulke, Spreckels Sugar Company, on Spreckels' Plant Breeding Farm.

Dates of Planting and Harvest: February 12, 1970; October 6, 1970.

Experimental Design: Randomized complete block - 8 replications. Plot size was 2 rows 50' long, rows averaging 20" apart.

Determination of Beet Yield, Sucrose Percentage, and Purity: Entire plot weighed for yield; 2 random 25# samples per rep. for S%; 2 samples per rep. bulked for 1 purity sample, only 6 reps. in purity data.

Leaf Spot Exposure: None

Curly Top Exposure: None

Other Diseases and Pests: None

Reliability of Test and Remarks: Excellent. Crop grown without any applied fertilizer.

Table 9 . Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Warren Tract, Fort Collins, Colorado (Exp. 1A)

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100'	Leaf ^{1/} spot
		Gross	Beets			
		sucrose				
		Lbs.	Tons	%	No.	
Acc. 2707	1	3036	13.23	11.42	116	5.2
SP 691202H02	2	3349	13.56	12.35	114	3.3
SP 671203H08	3	3197	12.79	12.51	117	3.6
SP 691202H07	4	3028	12.12	12.50	114	3.8
SP 691203H02	5	3380	12.75	13.24	116	2.5
SP 691203H07	6	2850	11.20	12.73	112	3.3
SP 691206H02	7	3346	13.08	12.78	114	3.6
SP 691900H07	8	3287	12.76	12.86	118	3.7
SP 691201H02	9	3183	12.70	12.50	114	2.1
Acc. 2706	10	2400	10.69	11.22	115	6.3
GW 674-56C	11	3133	12.03	13.02	112	4.8
GWH 19-68R	12	3329	12.81	12.99	117	5.7
FC(504 x 502/2) x FC 904	13	3646	14.13	12.91	117	2.8
(FC 602 x SP 652016s1) x FC 904	14	3034	11.93	12.71	115	3.6
General mean		3157	12.56	12.55	115	3.9
CV %		8.6	7.7	3.7	4.4	12.6
LSD (.05)		313	1.11	.54	6	.56

^{1/} Basis of leaf spot grades: 0 = healthy; 10 = complete defoliation.

Conducted by: J. O. Gaskill, E. G. Ruppel, and L. W. Lawson

Dates of Planting and Harvest: May 4; October 19

Experimental Design: Randomized block; 6 replications; plots 2 rows x 20'; rows 22" apart.

Determination of Beet Yield and Sucrose Percentage: All beets in an accurately measured competitive-stand area (about 35' of row) in each plot were topped, washed, weighed, and analyzed as two samples for sucrose percentage.

Leaf Spot Exposure: Severe (artificially intensified).

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Reliability of Test: Very good.

Table 10. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Agronomy Farm, Fort Collins, Colorado (Exp. 6)

Seed no. or variety	Entry no.	Acre yield		Sucrose	Thin juice purity
		Recov.	Beets		
		Lbs.	Tons	%	
Acc. 2707	1	4159	17.45	14.01	94.50
SP 691202H02	2	4506	17.39	14.64	94.60
SP 671203H08	3	4648	18.30	14.33	94.60
SP 691202H07	4	4305	16.80	14.40	94.86
SP 691203H02	5	4882	17.99	14.96	95.68
SP 691203H07	6	4045	15.68	14.11	96.02
SP 691206H02	7	4791	18.23	14.73	94.91
SP 691900H07	8	5040	18.77	15.05	94.75
SP 691201H02	9	4246	16.39	14.48	95.05
Acc. 2706	10	4681	18.77	14.23	94.03
GW 674-56C	11	5136	18.63	15.46	94.70
GWH 19-68R	12	5675	20.68	15.50	94.47
FC(504 x 502/2)x FC 904	13	4885	18.23	15.05	94.72
(FC 602 x SP 652016s1) x FC 904	14	4591	17.49	14.62	95.19
General Mean		4685	17.91	14.68	94.86
CV %		9.85	8.09	3.92	1.06
LSD (.05)		620	1.58	.566	.99

Conducted by: G. A. Smith and R. J. Hecker

Dates of Planting and Harvest: April 30; October 19

Experimental Design: Randomized Block - 8 replications; plots 2 rows
x 20'; 22-inch rows.

Determination of Beet Yield and Sucrose Percentage: Entire plot weighed
for yield determination; sucrose determinations made on each row of the
two row plot.

Leaf Spot Exposure: Negligible

Curly Top Exposure: Negligible

Other Diseases and Pests: Negligible

Reliability of Test and Remarks: Very satisfactory. Stand was excellent
throughout the test, averaging approximately 121 plants per 100' of row
at harvest.

Table 11. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Experiment Station Farm, Longmont, Colorado

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100'	Thin juice app. purity
		Recov. sucrose	Beets			
		Lbs.	Tons	%	No.	
Acc. 2707	1	6611	24.75	15.26	106	93.72
SP 691202H02	2	7130	25.22	16.10	106	93.85
SP 671203H08	3	6641	23.75	15.70	104	94.15
SP 691202H07	4	5592	22.36	14.38	107	93.85
SP 691203H02	5	6996	25.19	15.96	107	93.90
SP 691203H07	6	6250	24.46	14.60	110	94.14
SP 691206H02	7	6744	24.75	15.43	109	94.13
SP 691900H07	8	6729	24.33	15.63	108	94.24
SP 691201H02	9	5625	21.57	14.97	98	93.45
Acc. 2706	10	6479	25.97	14.60	105	92.95
68MSH151	11	7261	24.61	16.81	109	93.81
GW761	12	6109	22.10	16.11	106	92.95
General mean		6514	24.09	15.46	106	93.76
CV (%)		11.73	8.03	4.74	6.65	0.892
LSD (.05)		942	2.43	0.914	8.52	0.968

Conducted by: Great Western Sugar Company (Alvin Erichsen, Akio Suzuki, and Dave Rademacher).

Dates of Planting and Harvest: Planted April 10, 1970; Harvested November 19, 1970.

Experimental Design: Triple Rectangular Lattice. 6 replications.

Determination of Beet Yield and Sucrose Percentage: Yield - (6 rows x 18 feet); Sucrose - (2 middle rows of 6-row plots).

Leaf Spot Exposure: None

Curly Top Exposure: None

Other Diseases and Pests: None

Reliability of Test and Remarks: Good

Table 12. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Plant Industry Station, Beltsville, Maryland

Seed no. or variety	Entry no.	Acre yield			Plants: per 100'	Leaf ^{1/} spot	Raw juice apparent purity
		Gross	Beets	Sucrose			
		sucrose					
		Lbs.	Tons	%	No.		%
Acc. 2707	1	4931	18.65	13.22	96	4.5	82.32
SP 691202HO2	2	4102	14.84	13.82	83	3.8	81.68
SP 671203HO8	3	4355	15.52	14.03	95	4.5	81.71
SP 691202HO7	4	3466	12.63	13.72	84	3.8	81.85
SP 691203HO2	5	4794	16.34	14.67	97	3.3	83.62
SP 691203HO7	6	4004	14.13	14.17	83	3.2	82.30
SP 691206HO2	7	5477	18.38	14.90	98	3.0	83.84
SP 691900HO7	8	4773	16.83	14.18	97	3.2	82.75
SP 691201HO2	9	6490	21.59	15.03	94	2.8	83.58
Acc. 2706	10	3431	13.80	12.43	97	5.3	80.58
SP 67550-02 x SP 6322-0	11	5627	17.26	16.30	95	3.3	84.05
SP 6922-0	12	5345	18.02	14.83	122	3.3	83.06
General mean		4732	16.49	14.28	37.94	3.68	82.61
CV %		7.36	8.16	5.10	13.7	10.10	1.37
LSD (.05)		702	2.72	1.46	N.S.	.75	2.28

^{1/} Basis of leaf spot grades: 0 = healthy; 10 = complete defoliation.

Conducted by: Gerald E. Coe.

Dates of Planting and Harvest: April 30; October 10.

Experimental Design: Randomized block - 3 replications; plots 4 rows x 20'; 24" rows.

Determination of Beet Yield and Sucrose Percentage: Entire 2 middle rows weighed. First 10 roots in each row taken for sucrose determination.

Leaf Spot Exposure: Severe (artificially intensified).

Curly Top Exposure: None

Other Diseases and Pests: Negligible

Reliability of Test and Remarks: Satisfactory

Table 13. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: San Juan Branch Exp. Station, Farmington, N. M.

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100'
		Gross	Beets		
		sucrose			
		Lbs.	Tons	%	No.
Acc. 2707	1	8079	21.8	18.55	100
SP 691202H02	2	7585	20.1	18.88	100
SP 691203H02	5	7556	19.8	19.04	100
SP 691206H02	7	7352	19.6	18.76	100
SP 691201H02	9	6276	17.2	18.18	100
Acc. 2706	10	8017	21.8	18.55	100
Holly Sugar Co.HH-7 11		8105	21.5	18.82	100
General mean		7567	20.3	18.67	
CV (%)		11.4	14.6	2.67	
LSD (.05)		1015	n.s.	n.s.	

Conducted by: E. J. Gregory, New Mexico State University, San Juan Branch Station, Box 1018, Farmington, New Mexico 87401.

Dates of Planting and Harvest: Planted May 8; harvested October 26.

Experimental Design: Randomized complete block with 6 replications; plots 2 rows by 17 feet. Rows 20" apart. Beets thinned to one per foot of row.

Determination of Beet Yield and Sucrose Percentage: Yield - 2, 20-inch rows, 13' long; % sucrose - 1, 25-lb. sample per plot.

Leaf Spot Exposure: None

Curly Top Exposure: None

Other Diseases and Pests: None

Reliability of Test and Remarks: Good: This test was conducted on new land that had previously grown three green manure crops, two of Haygrazer (Sudangrass Sorghum Hybrid) and one of T.P. Rye. Relatively high sucrose levels may be due, in part, to a rather flaccid condition of the beets at the time of sucrose analysis. Plastic bags, torn in transit, resulted in a loss of moisture from most samples.

Table 14. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Willcox, Arizona; with Thimet and pre-plant fertilizer.

Seed number or variety	Entry no.	Acre yield		Sucrose	Plants: per 100'	Leaf ^{1/} spot	No. of reps
		Gross sucrose	Beets				
		Lbs.	Tons	%	No.		
Acc. 2707	1	5640	26.4	10.7	94	5.8	5
SP 691202HO2	2	5660	23.4	12.1	74	5.1	4
SP 671203HO8	3	7460	28.5	13.1	110	4.4	6
SP 691202HO7	4	6620	27.6	12.0	94	5.9	4
SP 691203HO2	5	7920	30.0	13.2	127	3.9	5
SP 691203HO7	6	6940	29.9	11.6	104	4.4	6
SP 691206HO2	7	6300	27.9	11.3	106	4.2	5
SP 691900HO7	8	7820	30.8	12.7	101	3.0	6
SP 691201HO2	9	7960	30.4	13.1	143	3.8	3
Acc. 2706	10	6528	31.5	10.4	107	7.5	5
H69543	11	6180	29.4	10.5	117	6.6	3
S-501H2	12	7040	29.3	12.0	104	4.2	4
General mean		6925	28.8	11.9	107	4.9	
CV (%)		3.42	2.25	1.62	---	---	
LSD (.05)		NS	NS	-----	---	---	

^{1/} 1 = No leaf spot to 10 = complete defoliation. An average of two readings on August 27, 1970 and September 24, 1970.

Conducted by: Spreckels Sugar by J. A. Dunlap on Jay Yamasaki's Lease.

Dates of Planting and Harvest: February 23, 1970, October 30, 1970.

Experimental Design: Completely Randomized Design with unequal number of replications. Plot size was 2 rows 50 feet long, rows averaging 20" apart.

Determination of Beet Yield and Sucrose Percentage: Entire plot weighed for yield; 2 random 25 lb. samples per rep. for S%.

Leaf Spot Exposure: Severe, despite fungicide applications.

Curly Top Exposure: Good protection (by Thimet) in the area represented by this table.

Other Diseases and Pests: None

Reliability of Test and Remarks: Poor. The entire experimental area received NH₃ (200#), disced in crosswise prior to listing, and a side-dress application of 10-10-5 fertilizer (200#). A preplant application of 11-37-0 fertilizer (200#) with Thimet (1# active ingredient), intended for the entire area, was inadvertently omitted on 5 beds. The entire area received four 5-oz. applications of Mertect 360 for Cercospora (leaf spot) control. Because of the omission of the pre-plant fertilizer and Thimet treatment on part of the area, the results were analyzed as 2 completely randomized tests with unequal numbers of replications in each test. The results shown on this page ("with Thimet and pre-plant fertilizer") indicate highly significant differences among varietal means for percent sucrose, and nonsignificant differences for beet yield and gross sucrose.

Table 15. Cooperative agronomic test of LSR-CTR varieties, 1970
Location: Willcox, Arizona; without Thimet and pre-plant Fertilizer.

Seed number or variety	Entry no.	Acre yield		Sucrose	Plants per 100'	Leaf ^{1/} spot	No. of reps
		Gross sucrose	Beets				
		Lbs.	Tons	%	No.		
Acc. 2707	1	2900	13.8	10.5	84	4.8	3
SP 691202H02	2	2560	12.1	10.6	59	5.7	4
SP 671203H08	3	1660	10.6	7.8	64	6.1	2
SP 691202H07	4	3740	19.7	9.5	87	5.2	4
SP 691203H02	5	3100	14.2	10.9	71	4.9	3
SP 691203H07	6	3320	18.0	9.2	79	5.3	2
SP 691206H02	7	3300	14.7	11.2	62	4.5	3
SP 691900H07	8	2700	12.7	10.6	69	3.9	2
SP 691201H02	9	1000	4.5	11.0	50	3.5	5
Acc. 2706	10	3580	22.4	8.0	70	6.5	3
H69543	11	3140	18.0	8.7	71	6.8	5
S-501H2	12	1940	9.1	10.7	60	4.9	4
General mean		2745	13.9	10.0	69	5.2	
CV (%)		8.08	2.94	4.40			
LSD (.05)		NS	---	NS			

^{1/} 1 = no leaf spot to 10 = complete defoliation. An average of 2 readings on August 27, 1970 and September 24, 1970.

Conducted by: J. A. Dunlap, Spreckels Sugar Company, on Jay Yamasaki's lease.

Dates of Planting and Harvest: February 23, 1970, October 30, 1970.

Experimental Design: Completely randomized design with unequal number of replications. Plot size was 2 rows 50' long, rows averaging 20" apart.

Determination of Beet Yield and Sucrose Percentage: Entire plot weighed for yield; 2 random 25# samples per rep. for S%.

Leaf Spot Exposure: Severe, despite fungicide application.

Curly Top Exposure: Severe in the area represented by this table.

Other Diseases and Pests: None

Reliability of Test and Remarks: Poor. This portion of the test came from the non-treated (Thimet and pre-plant fertilizer) beds. Varietal means were highly significant ($P=.01$) for root yield, but non-significant for gross sucrose and percent sucrose.

VARIABILITY OF SINGLE-SPORE ISOLATES OF *CERCOSPORA BETICOLA*

E. G. Ruppel

Growth habits and cultural characteristics of 14 isolates of *C. beticola* Sacc. from sugarbeets growing in widely scattered areas of Colorado were reported previously (Sugarbeet Research, 1969 Report, p. D36-D38). Results reported herein compare the same isolates in spore production, spore morphology, and pathogenicity in different sugarbeet lines.

Sporulation.--Spore production of the isolates grown for 7 days on sugarbeet leaf extract agar in an incubator at 15 C under continuous fluorescent light was compared (Table 1). A randomized block design was used with three replications. An analysis of variance revealed significant differences in spore production among isolates.

Spore morphology.--The length of 50 spores having four or more cells was measured for each isolate (Table 1). Average cells/spore also were calculated. An analysis of variance indicated significant differences among isolates in spore length and number of cells/spore.

Pathogenicity.--Standardized spore suspensions were sprayed on 3- to 4-week-old sugarbeet seedlings. The seedlings were held in a mist chamber for 5-6 days at 100% relative humidity and 25-27 C under continuous fluorescent light, and then transferred to a greenhouse bench where temperature was approximately 25-27 C. In test 1, each isolate was inoculated to sugarbeet lines R & G Pioneer (a highly susceptible open-pollinated variety) and US 201 (a highly resistant S₁ line). A randomized block design was used with four replications. In test 2, R & G Pioneer, SP 632028s1 x FC 901 (a hybrid of intermediate resistance), and FC(504 x 502/2) x SP 6322-0 (a highly resistant hybrid) were inoculated. A randomized block design was used with three replications. In both tests disease ratings of 0 to 5 in ascending order of severity were made 14 days after inoculation.

An analysis of variance of test 1 indicated no significant differences among isolates as measured by disease severity (Table 1). The interaction of isolates x lines also was not significant. The difference between lines, however, was highly significant, with Pioneer more severely affected than US 201 regardless of isolate.

In test 2 differences among isolates and lines were highly significant. Means of disease ratings for isolates are presented in Table 1. Again, there was no significant interaction between isolates and lines. In this test, the highly resistant line was significantly better than the intermediately resistant and susceptible lines, which were not significantly different from each other.

Table 1. Sporulation, spore morphology, pathogenicity in sugarbeet and growth of 14 isolates of Cercospora beticola from eastern Colorado^{1/}

Isolate	Spore production ^{2/}	Spore length ^{3/}	Cells per spore ^{3/}	Disease rating ^{4/}		12-day growth on SBLEA ^{6/}
	(X10 ⁴)	(microns)		Test 1 ^{5/}	Test 2	
C-1	45.2 bc	88.5 abc	11.3 ab	2.0	1.6 bc	27.7 d
-2	29.3 c	78.0 cde	9.7 bcde	2.0	1.3 c	32.2 a
-3	49.7 bc	69.5 de	8.4 ef	2.3	2.3 ab	27.7 d
-4	63.3 abc	85.6 bc	9.8 bcde	2.0	2.1 ab	28.0 cd
-5	52.3 bc	77.1 cde	9.6 cde	1.9	2.3 ab	27.8 d
-6	69.5 ab	87.9 abc	10.4 abcd	2.1	2.0 ab	30.5 ab
-7	26.7 c	86.7 abc	10.1 bcd	1.3	1.6 bc	31.0 ab
-8	59.5 abc	93.7 ab	10.5 abc	2.3	2.1 ab	31.8 ab
-9	49.6 bc	83.8 bc	9.1 cdef	1.6	2.3 ab	30.2 abc
-10	95.1 a	82.1 bcd	9.2 cdef	2.1	2.0 abc	30.2 abc
-11	70.1 ab	78.8 cd	8.8 def	1.9	2.6 a	29.5 bcd
-12	55.6 abc	99.3 ■	11.9 a	1.9	2.2 ab	31.5 ab
-13	61.7 abc	79.7 cd	9.2 cdef	2.4	2.6 a	31.5 ab
-14	45.2 bc	66.3 e	7.8 f	2.8	2.0 abc	28.0 cd

^{1/} Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

^{2/} Means of 3 replications.

^{3/} Means of 50 spores.

^{4/} Means of 4 replications of 2 sugarbeet lines in test 1 and 3 replications of 3 sugarbeet lines in test 2; disease ratings of 0 to 5 in ascending order of severity.

^{5/} Differences among means nonsignificant.

^{6/} Growth on sugarbeet leaf extract agar (SBLEA) reported previously; means of 3 replications.

Discussion

Significant differences among Cercospora beticola isolates in spore production, spore morphology, and their pathogenic capability indicate that several races of the fungus exist in Colorado. However, the practical importance of the multi-race situation is questionable.

All isolates were somewhat similar in the severity of leaf spot incited in sugarbeet seedlings. At least, differences in severity were not consistent between tests, and no one isolate could be designated as always being more virulent than another. Under conditions ideal for leaf spot in the field, all 14 isolates presumably would be capable of inciting a severe epidemic.

Differences in ability to produce spores could be an important consideration in field epiphytotics. Under favorable conditions, isolates that consistently sporulate heavily would be able to produce an abundance of secondary and tertiary inoculum for repeated cycles of leaf spot infection.

Most important, perhaps, is the nonsignificant interaction between isolates and sugarbeet lines obtained in both pathogenicity tests. In Colorado, at least, lines selected for resistance to one isolate should be resistant to most other isolates from within the state. Further tests are needed to determine if lines selected at Ft. Collins are equally resistant to isolates of Cercospora from other geographical areas. Cooperative tests among several research facilities in the United States (e.g. Sugarbeet Research Reports 1963, 1964, 1965) seem to indicate that lines developed for leaf spot resistance in one area also are resistant in other sugarbeet regions.

Correlation studies indicated that neither growth on sugarbeet leaf agar (Table 1) nor spore length was associated with disease severity (test 2) ($r = -.23$ and $-.10$, respectively). No association was found between spore production and disease severity in test 1 ($r = +.25$); however, disease severity in test 2 was associated with spore productivity ($r = +.52^{**}$). Thus, growth rate or spore length seem unsuitable for determining the potential virulence of unknown isolates of C. beticola; spore production may be useful in classifying isolates.

SUGARBEET LEAF AMINO ACIDS AND THEIR ROLE IN CERCOSPORA LEAF SPOT RESISTANCE

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J. O. Gaskill and G. A. Smith

Introduction

The chemotherapeutic effect of amino acids and amino acid analogues in relation to leaf fungal diseases has been studied since some investigators observed an increase in resistance in leaves after injection of different amino acids into the petioles. Much work has been done also on the study of antibiotic like substances which are formed in plant tissues in response to infection. Several amino acids have been found to be effective in the formation of these substances, especially L-valine, DL-norleucine, DL-norvaline and L-methionine. Some of these antibiotic like chemicals have been isolated and identified and all of them so far identified contain aromatic rings usually with one or more benzene rings. The phenolic compounds present in plant tissues are thought to be positively associated with the disease resistance mechanism in some way and some believe that the amino acid-phenolic balance may be interrelated in the formation of the antibiotic substances in response to infection. Some amino acids also have the capacity to act as antimetabolites and may affect the metabolism of the pathogen or of the host.

We first studied the relation of sugarbeet amino acids to Cercospora leaf spot infection in 1968 and 1969. The 1968 study was an introductory study made on sugarbeet leaves from healthy and Cercospora infected plants of four varieties, two leaf spot resistant (LSR) and two leaf spot susceptible (LSS).

The 1969 study included three of the varieties used in 1968. They were: US 201, a LSR relatively heterogeneous variety, GWI-29, a LSR inbred, and R & G Pioneer, a LSS heterogeneous variety. In place of the LSS inbred 52-407 used in 1968, the highly LSS inbred 52-334 was used in 1969. Four summer harvests of leaves from healthy and Cercospora infected plants were made as the Cercospora infection progressed on the inoculated plants during the summer. In 1968 and 1969 the replications of each population of leaf samples were pooled to reduce the number of time consuming amino acid analyses.

The phenolic compound, 3-hydroxytyramine, was included in the leaf study both years. Earlier studies had shown that this phenolic compound, when oxidized, was highly toxic to Cercospora beticola Sacc. when grown in pure culture. Also the leaves of LSR sugarbeet varieties usually contain larger amounts of this phenolic compound than leaves of LSS varieties. However, we have found exceptions to this which shows that Cercospora resistance is not determined by the phenolic content alone.

The 1968-69 results showed differences in some of the amino acid patterns between LSR and LSS varieties, and differences in their response to the Cercospora infection. A publication on these results is in process but complete statistical analyses could not be made because of the pooled replications in the amino acid analyses.

A 1970 experiment was designed to continue the study of leaf amino acids and their possible role in Cercospora leaf spot resistance. The object of the study is to investigate in more detail the response of the amino acids to Cercospora leaf spot infection, the difference in response between LSR and LSS varieties, and the possible interrelationship between certain amino acids and the phenolic compound, 3-hydroxytyramine. Root yield factors and phosphated thin juice components will be studied also to determine the effect of Cercospora leaf spot infection on sugarbeet quality.

Materials and Methods

Duplicate plantings of six sugarbeet populations with three replications were planted May 4 in a randomized block design and grown under irrigation at the CSU Agronomy Research Center and the Disease Farm Nursery at Fort Collins, Colorado.

Three heterogeneous, one inbred, and two hybrid varieties were selected to give a wide range of Cercospora resistance. The varieties used, with a brief description of each, follows.

Entry No.	Population	Description
1	52-334	Highly LSS, inbred, low vigor
2	R & G Pioneer	LSS, heterogeneous
3	US 201	LSR, relatively heterogeneous
4	US H9B	LSS, 3-way commercial hybrid
5	SP 5822-0	LSR, heterogeneous
6	FC(504x502/2) x SP 6322-0	LSR, 3-way hybrid

Plants at the Disease Farm were inoculated with Cercospora beticola on July 6. Leaves were harvested on three dates during the summer as the Cercospora infection progressed on the diseased plants. The harvests were made in the morning on each date from each location and as near the same time as possible. One middle-aged, fully expanded leaf was selected from each plant of each plot to make a single sample for that plot. The

samples were transferred to the laboratory as soon after harvest as possible and the amino acid samples were prepared and frozen until individual plot analysis could be made on the amino acid analyzer. Individual plot samples from US H9B and the FC hybrid were also prepared immediately after harvest for 3-hydroxytyramine analysis. These two varieties were selected for 3-hydroxytyramine analysis at this time because the other four populations had been analyzed for the phenolic compound several times previously. Leaves were harvested on July 30, August 10, and August 19. At the time of the first harvest the susceptible varieties showed considerable infection in the older leaves and first signs of infection in the younger leaves. The resistant varieties showed no visible signs of infection except in the oldest leaves on the plants. The three susceptible varieties were highly infected on the second harvest date while the two resistant varieties, US 201 and the FC hybrid, still showed very little infection except in the oldest leaves. SP 5822-0 showed moderate infection. On the third and last harvest date the susceptible varieties had reached the height of infection with complete necrosis in the older leaves, especially in 52-334 and R & G Pioneer. Much less infection was evident in the resistant varieties. Two leaf spot readings were made during the summer.

Roots were harvested at both locations on October 16. We determined root yield and sucrose content on the roots from which phosphated thin juice was later recovered at the time of purity determination.

The thin juice will be analyzed for total nitrogen, nitrate nitrogen, amino nitrogen, betaine, chloride, sodium, potassium and possibly other nonsugar components. Thin juice samples will also be analyzed for individual amino acids and amides. All analyses will be done on single plot basis.

Results and Discussion

Amino acid results on this experiment are not yet available because the leaf and thin juice analyses have not been completed.

To reduce the chance of variables due to difference in moisture content of the leaf and the effect of necrosis, all results on the leaf tissue will be converted to dry leaf weight basis instead of fresh leaf weight as used in previous years. Thin juice results will be converted to the refractive dry substance of 10 (RDS 10).

Four of the six varieties used in this experiment had been used in previous years to study the possible role of 3-hydroxytyramine in Cercospora leaf spot resistance and, therefore, were not analyzed for the phenolic compound in this study. The leaves from one, four, and six harvests per summer were analyzed for 3-hydroxytyramine in 1967, 1968, and 1969, respectively. The 1967 single harvest included leaves from disease free

plants only, but the four and six harvests per summer in 1968 and 1969 included analyses of leaves from both disease free and Cercospora infected plants. Leaves from US 201, the LSR relatively heterogeneous variety, consistently contains more of the phenolic compound than is found in less resistant varieties. Usually the phenolic content of the leaves is lower during the earlier growing season but increases during the latter half of July, reaches a peak about the second week in August, then tapers off somewhat in late August and in September. The leaf phenolic content of the heterogeneous LSR variety, SP 5822-0, has not been studied quite as extensively as US 201, but much the same pattern has been found in the development of the phenolic content of the leaves, but with a somewhat lower concentration than found in US 201. The highly leaf spot susceptible inbred, 52-334, always ranks very low in the phenolic content of the leaves. In early July the phenolic content is usually about one-tenth the amount found in the US 201 leaves harvested at the same time. It too shows some increase in late July and early August with slightly more in the diseased leaves than in the disease free leaves.

In previous years the analysis results were calculated on fresh leaf weight basis rather than dried leaf weight basis and some of the change in phenolic content may be due to incorrect fresh leaf weight as the result of moisture loss caused by disease infection and necrosis; some increase may result also from the plant's response to the infection. The LSS heterogeneous R & G Pioneer is one Cercospora susceptible variety which has shown moderately high 3-hydroxytyramine content in leaves from healthy and infected plants and yet shows high leaf spot infection. Usually the phenolic content of the diseased leaves is higher than in leaves from disease free plants harvested at the same time; again, loss of leaf moisture as well as plant response to the disease may cause this.

Our earlier studies on Cercospora resistance had not included the two 3-way hybrids, FC(504x502/2) x SP 6322-0 and US H9B, therefore in this 1970 experiment we analyzed the leaves from these hybrid plants, both healthy and Cercospora infected for 3-hydroxytyramine at each harvest. The means, healthy (H) and diseased (D), for each harvest date are given in the following table in mg 3-hydroxytyramine per 100 g dried leaf.

Population	Dates of Harvest					
	July 31		August 10		August 19	
	H	D	H	D	H	D
FC(504x502/2) x SP 6322-0	842.0	1020.3	874.2	903.3	590.7	1202.8
US H9B	934.8	692.3	636.1	764.2	528.8	700.2

Inoculation had been made at the Disease Farm Nursery on July 6, 25 days prior to the first harvest. The FC hybrid leaves, when harvested on July 31, showed no visible infection, but the 3-hydroxytyramine content in the leaves from the inoculated plants was somewhat higher than from the healthy plants; the difference on the second harvest date is not as significant, but the third harvest date showed a large difference between the leaves of the healthy and Cercospora infected plants.

The 3-hydroxytyramine results for the hybrid US H9B were lower than for the FC hybrid except in the healthy leaves at first harvest. The infected US H9B leaves showed the lesser amount of the phenolic compound on July 31, but at the two later harvests the infected leaves contained greater amounts of 3-hydroxytyramine than the healthy leaves. We have found other susceptible varieties such as R & G Pioneer and even 52-334 respond in the same way; that is, a decrease in the phenolic content of the diseased leaves during early infection below what is present in healthy leaves, but an increase in the infected leaves over the healthy leaves later in the summer as the disease progresses.

Leaf spot readings, shown in the following table, were taken at the Disease Farm Nursery on July 27 and August 12. The standard leaf spot rating scale was used (0 = no infection, 10 = complete necrosis).

Population	Leaf Spot Reading Population Means (3 Reps)	
	July 27	August 12
FC(504x502/2) x SP 6322-0	1.67 a*	1.83 a
US 201	1.00 a	1.33 a
SP 5822-0	2.33 bc	3.00 b
52-334	3.00 cd	7.33 d
US H9B	2.67 cd	5.67 c
R & G Pioneer	4.00 d	7.00 d

* Means followed by the same letter do not differ significantly (5%).

The two LSR varieties, US 201 and the FC hybrid, showed no significant difference in leaf spot infection on either date. SP 5822-0, also rated LSR, showed considerably more infection. Of the three LSS varieties, the hybrid US H9B showed the least amount of infection on both dates, but more than SP 5822-0. R & G Pioneer and 52-334 showed no significant difference on either date. All LSS varieties showed considerably higher infection on August 12 than on July 27.

Plot character population means (3 replications) for healthy (H) and Cercospora diseased (D) plants showed considerable difference in disease effect between LSR and LSS plants on all factors except purity. Means and tests of differences between populations are shown in the following tables [population FC(504x502/2) x SP 6322-0 indicated as FC hybrid].

Population	Plot weight (kg)		Sucrose (%)	
	H	D	H	D
52-334 (LSS)	11.85 d*	6.83 c	11.10 b	9.47 c
R & G Pioneer (LSS)	21.63 b	13.68 b	12.67 ab	11.93 b
US 201 (LSR)	11.83 d	8.82 c	11.57 ab	11.67 b
US H9B (LSS)	25.68 a	18.74 a	12.63 ab	11.53 b
SP 5822-0 (LSR)	18.14 c	14.44 b	12.40 ab	12.33 ab
FC Hybrid (LSR)	23.45 ab	20.58 a	13.20 a	13.30 a

* Means followed by the same letter in each column of values do not differ significantly (5%).

Population	App. purity (%)		Rec. sucrose (kg)	
	H	D	H	D
52-334 (LSS)	85.01 b*	82.40 b	.90 c	.41 f
R & G Pioneer (LSS)	89.67 ab	88.97 a	2.15 ab	1.26 d
US 201 (LSR)	91.36 a	91.87 a	1.12 c	.86 e
US H9B (LSS)	88.19 ab	89.85 a	2.44 a	1.70 b
SP 5822-0 (LSR)	90.01 ab	92.11 a	1.79 b	1.48 c
FC Hybrid (LSR)	92.07 a	91.58 a	2.61 a	2.26 a

* Means followed by the same letter in each column of values do not differ significantly (5%).

When we compare the population means for disease free and diseased plots the three LSR varieties show a similar pattern of response to Cercospora infection in all the root character means except purity. Each showed a similar decrease in plot weight and recoverable sucrose and only a small difference in percent sucrose. The FC hybrid was significantly higher in plot weight and recoverable sucrose than

SP 5822-0 and US 201 under both disease free and diseased conditions. There was no significant difference between the three LSR varieties at either location in percent sucrose and apparent purity but the FC hybrid showed a slight decrease in apparent purity under diseased conditions while SP 5822-0 and US 201 showed an increase in purity.

The three LSS varieties grown at the Disease Farm Nursery showed lower plot weight, percent sucrose, and recoverable sucrose than those grown at the Agronomy Farm (disease free) and all except US H9B also showed lower apparent purity. US H9B gave significantly higher recoverable sucrose than R & G Pioneer and 52-334 under diseased conditions but not significantly higher than R & G Pioneer under disease free conditions.

The two 3-way cross hybrids were the best performing genotypes. US H9B gave slightly higher plot weight at the disease free location than the FC hybrid but because of slightly lower apparent purity and significantly lower sucrose and recoverable sucrose under diseased conditions its overall performance was below the FC hybrid.

When results are obtained for the thin juice analysis we can interpret more completely the effect of Cercospora infection on sugarbeet quality. The results from the amino acid analyses of the healthy and Cercospora infected leaves should show any differences in the amino acid patterns in LSR and LSS varieties and help in the evaluation of their possible role in Cercospora resistance. It is probable that resistance to each type of infection is determined not by one substance, however active it may be, but by the action of several substances entering into the defense mechanism reaction. To understand the biochemical nature of disease resistance the individual factors and their possible roles in disease resistance must be evaluated. Results from earlier work by several investigators point to amino acids having a role in the development of phytoimmunity.

THIN JUICE AMINO ACIDS AND OTHER QUALITY CHARACTERS IN LEAF SPOT INFECTED AND NONINFECTED SUGARBEETS

R. J. Hecker, G. W. Maag, E. G. Ruppel,
J. O. Gaskill and P. A. Whitaker

A 1969 experiment was designed to study the effect of leaf spot infection and genetic resistance of sugarbeet on the relative quantities of individual amino acids in the leaves and phosphated thin juice. The leaves were sampled throughout the disease development period. The thin juice was prepared from roots harvested October 27. Results on the leaf amino acids were preliminarily reported in our 1969 report and are currently being prepared for publication. In this section we are reporting the results of the thin juice analyses.

The study of thin juice amino acids and other non-sugar components in a set of varieties, both leaf spot infected and disease-free, had two objectives: (1) a quality comparison of diseased and disease-free beets, particularly with respect to the free amino acids, and (2) to look for relationships of specific thin juice non-sugars (particularly amino acids) with leaf spot resistance or susceptibility.

With respect to the first objective, detailed quality comparisons of leaf spot infected and noninfected beets have never been reported, although it has been well established that a serious leaf spot infection is quite deleterious to root yield and sucrose content. With respect to the second objective, we realize that the thin juice is somewhat remote from the effect of leaf spot infection, the thin juice being a purified product of roots harvested 6 to 8 weeks after the peak of the disease epidemic. However, the possibility of meaningful relationships makes the examination worthwhile.

Materials and Methods

The populations in this experiment were planted in a randomized-block design and grown under irrigation at the Colorado State University Agronomy Research Center (disease-free) and at our Disease Farm leaf spot nursery at Fort Collins, Colorado (the two areas were about $\frac{1}{2}$ mile apart).

Populations were selected to give a wide range of Cercospora leaf spot resistance, and included inbreds, F_1 hybrids, and heterogeneous varieties. Twelve populations with three replications were planted April 23 at the Agronomy Research Center. Eight of the 12 populations with four replications were planted in the leaf spot nursery May 14. The Disease Farm plants were inoculated with Cercospora beticola July 16. The roots were harvested at both locations on October 27. Root yields and recoverable sugar are reported as kg per 20 ft single row plot.

The 12 populations with a brief description of each appear in Table 1.

Root yield and sucrose were determined on the roots from which phosphated thin juice was prepared for purity determinations. Recoverable sucrose, a function of root weight, sucrose, and purity, was calculated using an equation developed by the Great Western Sugar Company. Total nitrogen, amino nitrogen, nitrates (NO_3^-), betaine, sodium (Na), and potassium (K) were measured in the thin juice from each plot. These nonsugars are reported in milligrams per 100 ml of thin juice (mg/100 ml), adjusted to a refractive dry substance of 10 (RDS 10). A Technicon Amino Acid Analyzer was used for the individual amino acid analyses of thin juice prepared from individual healthy and diseased plots of entries 1, 2, 5, and 6 (US 201, GWI-29, R & G Pioneer, and 52-334, respectively). The first two entries were LSR and the latter two were LSS. All amino acids were measured in micromoles per 100 ml ($\mu\text{M}/100 \text{ ml}$) of thin juice at RDS 10. Four populations provided the maximum number of analyses we could make due to the time involved.

Table 1. List of sugarbeet populations compared under leaf spot and disease-free conditions, 1969.

Population	Description
1. US 201	LSR ^{1/} , heterogeneous
2. GWI-29	LSR, inbred
3. SP 5822-0	LSR, heterogeneous
4. GW 359-52R ^{2/}	Moderate LSR, heterogeneous
5. R & G Pioneer	LSS ^{1/} , heterogeneous
6. 52-334	Highly LSS, inbred
7. 51-319 ^{2/}	LSS, inbred
8. 52-305 CMS x 52-407, F ₁	LSS, homogeneous
9. 54-315 ^{2/}	LSS, inbred
10. 52-305 CMS	Moderate LSS, inbred
11. 52-305 CMS x 52-334, F ₁	LSS, homogeneous
12. 52-407 ^{2/}	LSS, inbred

^{1/} LSR = leaf spot resistant; LSS = leaf spot susceptible

^{2/} Populations grown only in the disease-free field

Results and Discussion

Table 2 lists the populations, leaf spot ratings, recoverable sugar, and sugar yield components. Recoverable sugar, root yield, and sucrose were lower, without exception, when infected with leaf spot. The effect of leaf spot on purity, however, seemed to be dependent on genotype. In the disease nursery the resistant lines tended to be higher or at least as high in purity, while the purity of some susceptible lines was higher and that of others was lower than in the disease-free test. The purity mean was higher in the disease nursery. The purity and sucrose percentages were not highly related, particularly in the disease nursery. The exceptionally low sucrose under disease conditions must have been at least partly due to the effect of leaf spot since, among other things, total nitrogen in the thin juice was lower in the diseased plots. Figure 1 compares graphically the amount of sodium (Na), potassium (K), total nitrogen (N), amino nitrogen (N), betaine, and nitrate (NO₃) in the thin juice of those eight populations common to both the disease and disease-free tests. Entries 1, 2, and 3 were classified as resistant, entries 5, 6,

Table 2. Leaf spot ratings (0 = no infection to 10 = complete defoliation) and sugar yield characters of sugarbeet populations which were leaf spot infected (D) and disease-free (H), 1969.

Population	LS Rating	Recov. Sugar (kg)		Root Yield (kg)		Sucrose (%)		Thin juice purity (%)	
		H	D	H	D	H	D	H	D
1. US 201	2.2 ^{1/} e	.97 cd	.56 cd	10.3 e	8.0 c	12.6 bcd	8.6 cd	88.2 ab	89.8 ab
2. GWI-29	4.0 cd	.86 cd	.47 cd	9.4 e	7.4 cd	12.5 bcde	8.3 d	88.2 ab	87.7 bc
3. SP 5822-0	2.8 de	1.75 a	1.69 a	17.9 bc	17.7 a	12.7 bcd	11.2 a	88.8 a	92.8 a
4. GW 359-52R		2.09 a		20.2 ab		13.4 ab		88.8 a	
5. R & G Pioneer	5.5 b	1.97 a	.63 c	19.7 ab	13.3 b	13.0 abc	6.9 e	88.8 a	84.4 c
6. 52-334	7.2 a	.74 d	.36 d	10.3 e	5.7 cd	11.8 cdef	8.8 cd	82.1 c	86.4 bc
7. 51-319		.91 cd		17.8 bc		7.9 g		83.6 bc	
8. 10 x 12, F ₁	6.0 ab	1.99 a	1.28 b	21.2 a	15.8 a	13.3 ab	10.6 ab	86.0 abc	88.7 ab
9. 54-315		1.08 cd		14.4 d		11.3 ef		84.1 abc	
10. 52-305 CMS	5.0 bc	1.06 cd	.42 d	10.3 e	5.5 d	14.2 a	9.8 bc	86.4 abc	88.9 ab
11. 10 x 6, F ₁	5.8 b	1.63 ab	1.12 b	17.5 bc	13.5 b	13.8 ab	10.7 ab	84.3 abc	89.1 ab
12. 52-407		1.26 bc		15.5 cd		11.5 def		85.6 abc	
Mean		1.37±.05 ^{2/}	.82±.02	14.6±.3	10.9±.3	13.0±.14	9.4±.13	86.6±.4	88.5±.5

^{1/} Means followed by the same letter do not differ significantly (5%); compare only means within columns.

^{2/} Means of healthy entries included only those 8 entries also in the disease nursery.

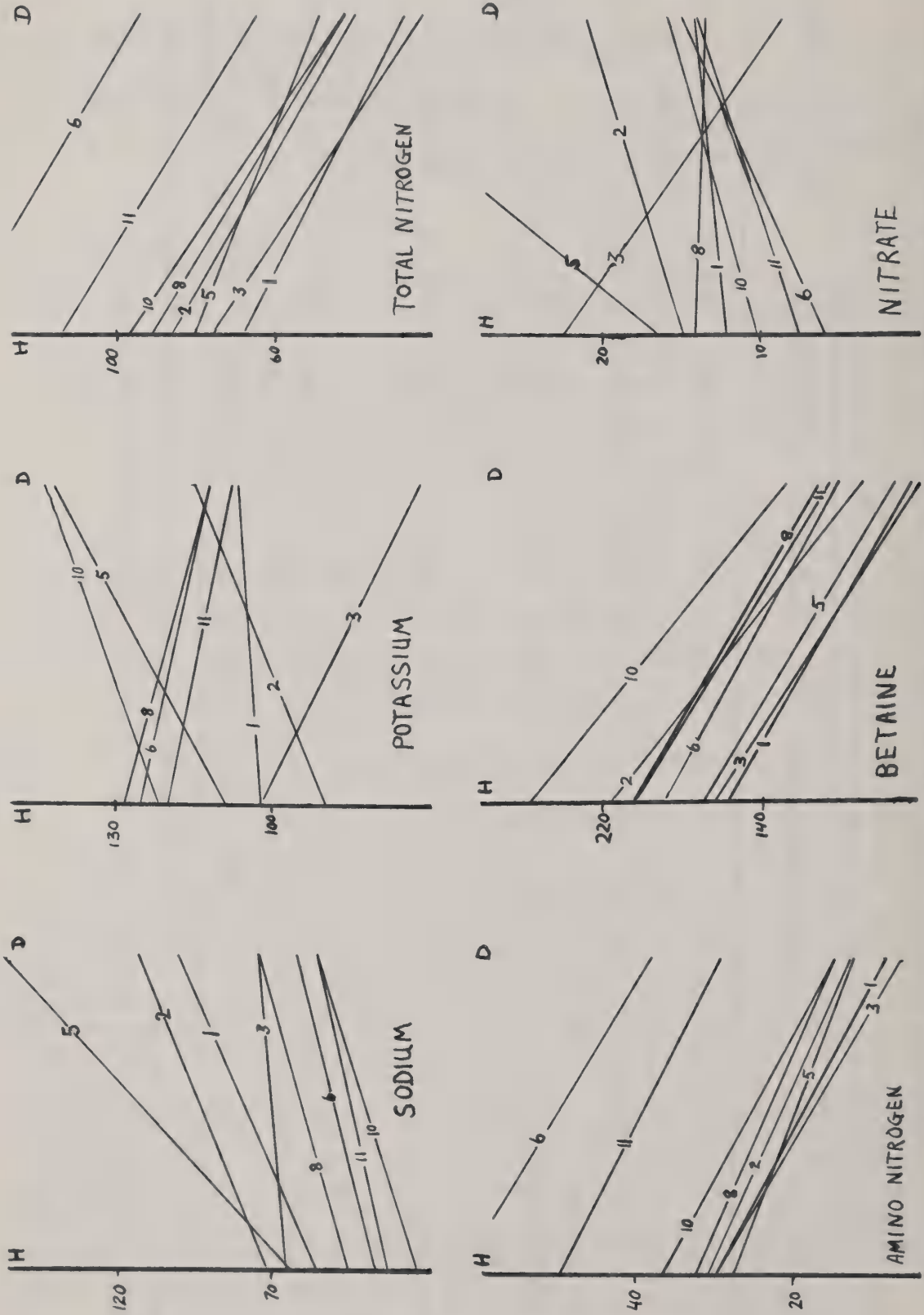


Figure 1. Thin juice non-sugars (mg/100 ml) to RDS 10) in healthy (H) and leaf spot diseased (D) sugarbeet plots, 1969; populations numbered as in Table 1.

8, and 11 were classified as susceptible, and entry 10 as moderately susceptible. Na was the only character which was consistently greater in thin juice from diseased plants. Total N, amino N, and betaine were consistently less. Considerable interaction of genotype with disease effect occurred for K.

Since the diseased and disease-free nurseries were planted at different dates, were at different locations, and had somewhat different cultural treatment, the effect of disease was undoubtedly confounded with these other factors. Certainly disease was partially responsible for the root yield and sucrose reduction. If more available soil nitrogen in the disease nursery also contributed to the sucrose reduction, it is paradoxical that total N, amino N, and betaine were lower. So there must have been unidentifiable interrelations of disease, planting date, treatment, fertility, etc., entering into the results. Even though the diseased plants were in the process of recovering during the last 8 weeks of the season, the reduced quantity of total N, amino N, and betaine indicates that the plants were not simulating juvenile or early season growth and development, a period when healthy beets are normally high in these compounds.

The individual amino acids in the thin juice (Table 3) appeared to have been affected by the leaf spot infection in much the same manner as total N, amino N, and betaine. The quantity of every measured amino acid and ammonia in populations 1, 2, and 5 in the disease nursery was lower than, or equal to, the corresponding value in the disease-free test. Population 6 (52-334) caused some exceptional interactions by exhibiting higher amino acids in 10 instances. 52-334 is a rather low vigor, highly leaf spot susceptible, inbred (approximately equivalent to S₈). At the peak of the leaf spot epidemic it was largely defoliated. Hence, it was under considerable physiological stress. Of course entry 2 (GWI-29) is also inbred (S₅) but is relatively resistant and suffered no defoliation. Entry 5 (R & G Pioneer) did suffer considerable defoliation but nonetheless responded to infection in a manner not greatly different than the resistant entries 1 and 2.

It would appear from this study that the severe leaf spot infection, together with other unidentifiable factors, caused a serious reduction in root yield and sucrose, particularly in the susceptible genotypes. These reductions were not necessarily accompanied by a reduction in thin juice purity. Any reduction in purity seemed to reflect a genotype by infection interaction. Purity and sucrose were not positively related between locations in the manner normally expected. The higher sodium in diseased plants might be expected, based on the sucrose results, but the lower levels of total N, amino N, and betaine were contrary to expectations. The lower concentrations of individual amino acids may also have been caused by the same combination of factors which caused the lower concentrations of total N, amino N, and betaine. Among the populations in this study, it appears that leaf spot infection primarily takes its toll by decreased root yield and sucrose without necessarily affecting quality.

Table 3. Individual amino acids in the thin juice ($\mu\text{M}/100\text{ ml}$) of leaf spot infected and disease-free sugarbeets.

Amino Acids	1. US 201		2. GWI-29		5. R & G Pioneer		6. 52-334		Mean	
	H	D	H	D	H	D	H	D	H	D
Aspartic acid	191 a ^{1/}	95 a	165 a	93 a	193 a	115 a	142 a	86 a	173±09	97±14
Threonine	30 b	6 b	19 c	9 b	29 b	13 b	59 a	41 a	34±01	17±03
Serine	227 b	65 b	222 b	95 b	245 b	113 b	799 a	861 a	373±39	284±50
Glutamic acid	345 b	165 b	299 b	158 b	334 b	213 b	531 a	366 a	377±16	226±08
Proline ^{2/}	-	22	45	16	-	16	61	85	53	35
Glycine	19 b	5 b	19 b	8 b	17 b	7 b	52 a	47 a	27±03	17±02
Alanine	94 b	22 b	59 b	38 b	70 b	31 b	193 a	384 a	104±11	119±24
Valine	34 b	7 b	23 b	9 b	35 b	12 b	66 a	81 a	40±02	27±05
Methionine	9 b	2 a	5 b	2 a	9 b	3 a	22 a	7 a	11±01	4±01
Isoleucine	53 b	8 b	30 b	7 b	59 b	9 b	148 a	63 a	73±08	22±05
Leucine	47 b	8 b	30 b	5 b	50 b	7 b	95 a	46 a	56±04	17±04
Tyrosine	61 b	3 b	14 c	2 b	77 b	4 b	157 a	39 a	77±06	12±05
Phenylalanine ^{2/}	3	1	2	2	2	2	3	5	3	3
Ammonia	527 b	94 b	561 b	131 b	425 b	153 b	1814 a	518 a	832±51	224±36
GABA	65 b	30 b	64 b	41 b	74 b	36 b	169 a	214 a	93±06	80±04
Lysine	6 a	2 b	2 a	2 b	4 a	2 b	4 a	16 a	4±01	6±01
Histidine	4 b	1 b	2 b	1 b	4 b	2 b	9 a	11 a	5±01	4±01
Tryptophan	8 ab	2 b	3 c	2 b	7 b	2 b	10 a	16 a	7±01	6±01
Arginine	11 a	2 b	2 a	2 b	12 a	2 b	5 a	23 a	8±02	7±01

^{1/} Means followed by the same letter do not differ significantly (5%); compare only H or D means within rows.

^{2/} Not included in the multiple range test.

The second objective was to look for relationships of individual amino acids with leaf spot resistance or susceptibility. There was no evidence of any such relationships. In fact, individual amino acids of entry 1 (US 201, LSR) and entry 5 (R & G Pioneer, LSS) were quantitatively affected by disease almost as if they were sib lines. Also various ratios of individual amino acids showed no relationship with leaf spot resistance or susceptibility. Hence, it appears that there was no predictable relationship between leaf spot resistance and individual amino acids in the thin juice of these roots at harvest.

STUDIES ON THE INHERITANCE OF RESISTANCE TO CERCOSPORA LEAF SPOT

G. A. Smith, E. G. Ruppel and J. O. Gaskill

We reported in 1969 (Sugarbeet Research, 1969 Report) on the heritability and probable number of genes involved in resistance to *Cercospora* leaf spot. A full report on the study will appear soon in the Journal of the American Society of Sugar Beet Technologists.

During 1970 we continued our inheritance studies. F_2 populations of US 201 x 52-334 and US 201 x 51-319 were grown under an artificially induced leaf spot epidemic. At the peak of the epidemic, leaf spot ratings were made on 310 individual plants from each F_2 population. These 310 plants were randomly chosen from the $600 \pm$ plants in each F_2 population. At the peak of the epidemic symptoms, 80 plants displaying high resistance (a disease rating of 1 or 2) and 80 plants displaying high susceptibility (a disease rating of 7 to 9) were selected from each of the F_2 populations.

The 310 randomly selected disease-rated plants from each F_2 will be self-pollinated under bags and the resulting F_3 lines grown under *Cercospora* conditions in plots. *Cercospora* leaf spot ratings will be made on entire plots. These data will be used in computation of narrow sense heritability estimates by regression of F_3 on F_2 .

The 80 plants selected for high resistance and the 80 plants selected for low resistance from each of the F_2 populations will be interpollinated and the progeny grown under leaf spot conditions. Leaf spot ratings will be taken on these high and low populations to determine the population mean disease rating. These mean values, the mean population value of the F_2 population and the broad and narrow sense heritability estimates will be used to determine the accuracy of the heritability estimates by comparison of the actual selection gain with predicted selection gain. Additional gene action and gene number estimates will also be obtained.

DIALLEL ANALYSES OF SUGARBEET CHARACTERS

G. A. Smith and R. J. Hecker

An 8-parent diallel mating was completed in early 1970 and planted in the field in the spring of 1970. CMS and fertile equivalents were utilized in all 8 genetically diverse inbred lines to obtain the complete diallel set. A randomized block experiment with 8 replications was established at two nitrogen fertility levels--0 and 250 lbs N. Data were obtained on the 28 F_1 's and the 8 inbred parents for root weight, fresh top weight, sucrose, purity, and recoverable sugar. Thin juice samples were saved for possible amino acid and/or other chemical analyses.

Diallel analyses are being performed on each of the above measured characters. From these analyses we will determine the type of gene action controlling each character and the effect of greatly differing fertility levels on gene action. We are currently developing the same diallel set to be grown in 1971. From the two years data we hope to be able to ascertain, with a high degree of accuracy, the types of gene action governing the sugarbeet traits and the effect of environment (year and fertility) on the expression of those genes.

STUDIES ON CHEMICAL INDUCTION OF POLLEN STERILITY IN SUGARBEET

Dianne R. Mason, R. J. Hecker and G. A. Smith

The development of male-sterile sugarbeets assures absolute crossing of desired strains. At present, this is possible only by the time-consuming introduction of cytoplasmic or genetic male sterility into strains destined for use as females. A more rapid but positive method of producing pollen sterility would be desirable.

If a chemical could be found which would interfere with pollen formation, then subsequent pollen produced would be aborted or sterile. FW-450 (sodium 2,3-dichloroisobutyrate) has been quite thoroughly investigated as a male gametocide in sugarbeet. Work at Ft. Collins (Sugarbeet Research Reports, 1960 and 1969) and at Salinas (4) has demonstrated that FW-450 is, at best, only partially effective. In cucumbers, a monoecious species, Ethrel (2-chloroethylphosphonic acid) was found to produce only female flowers when treatments were regularly maintained (3). Similar male flower repression occurred in butternut squash (1). Arsenic acid has been reported to have some male gametocidal effect in pearl millet (2). Earlier experiments at this station (Sugarbeet Research Report, 1969) indicated possible gametocidic effects using oestrone, a female animal hormone.

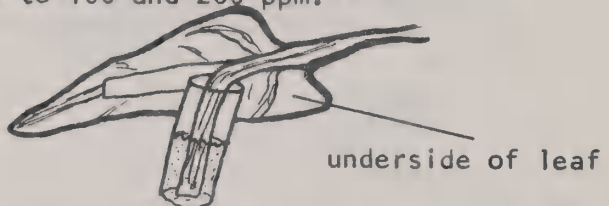
Experiment I

In a greenhouse experiment, oestrone, arsenic acid, and Ethrel^{1/} were compared for gametocidal effect on sugarbeet. Two genotypes,

^{1/} We gratefully acknowledge receipt of the Ethrel from Amchem Products, Inc.

inbred 52-334 and an open-pollinated variety, SP 5822-0, were used. The three chemicals were applied in two ways--(1) by mist sprayer and (2) by leaf midvein uptake. The midvein uptake involved cutting free, at the tip and sides, a section of leaf midvein and immersing it in 2 cc of solution in a vial. The vial was taped to the leaf and sealed with modeling clay (Fig. 1). The solution was usually assimilated in 24 hours or less, except for arsenic acid, which often required 3 or 4 days. Application intervals were: (1) weekly treatments commencing when the seed stalk was 4" high, and (2) a first treatment at the 4" stage with a second treatment when the first flowers were in the early bud stage. The concentrations of each chemical were: Ethrel, 50 and 100 ppm, arsenic acid, 100 and 200 ppm (except that initial applications were 2000 and 3000 ppm, based on the work in pearl millet), and oestrone, 30 ppm. Arsenic acid was extremely toxic to the plants at 2000 and 3000 ppm. Subsequent treatments were reduced to 100 and 200 ppm.

Figure 1.



Pollen viability of SP 5822-0 seemed relatively unaffected by any of the three chemicals. There were, unfortunately, some obvious CMS or genetic male sterile segregates in SP 5822-0 which we had failed to anticipate.

In the inbred 52-334, only Ethrel appeared to have an effect on pollen viability. Ethrel at 100 ppm, whether applied as spray or midvein, twice or weekly, resulted in pollen viability of 0 to 5%. At 50 ppm, pollen viability was up to 50%. Pollen viability of untreated checks was 52%. It should be noted, however, that inbred 52-334 is a relatively low vigor line and may be particularly susceptible to physiological stresses.

Ethrel caused a distinct shortening of the internodes in both populations when sprayed with 100 ppm and reduced total seed yield. However, there was no apparent effect on the germination of resultant seed.

Experiment II

Based on the above findings, a two replicate field experiment was conducted, using only Ethrel on two vigorous open-pollinated populations, GW 674-56C and C 817. The plants were sprayed with four concentrations of Ethrel (25, 50, 100 and 200 ppm) at two treatment frequencies. "Growth unit" plants were sprayed at about every four inches of flowering stalk growth, regardless of the day. "Monday-Thursday" plants were sprayed regularly on a calendar basis. Spraying in both cases began when the individual's flowering stalk reached two inches and was discontinued at anthesis of the first flowers. Pollen viability tests using tetrazolium bromide were performed approximately one week after the first flowers opened.

Shortened internodes were observed in the 200 ppm plants. There was also a noticeable increase in total seed yield in both populations when sprayed with 50 ppm, regardless of the time interval. For the 25, 50, and 100 ppm treatments pollen viability was not greatly different from that of controls (84%). In the 200 ppm treatments, the average viability was reduced to 39% in GW 674-56C. In population C 817, the 200 ppm treatments had an average viability of 64%. Some of this difference might be accounted for by the number of times each was sprayed (Table 1).

Table 1. The average number of times sugarbeet plants were sprayed and the % viable pollen.

Population	GU at 200 ppm	MT at 200 ppm	Check
GW 674-56C	10 (33%)	8 (45%)	(85%)
C 817	7 (73%)	9.5 (55%)	(83%)

It appeared to us that Ethrel, at 200 ppm, did have some gametocidal effect. However, the degree of induced male sterility was not adequate to be useful as a breeding tool. From previous experiments with FW-450, we consider FW-450 to be more effective as a gametocide than Ethrel, as we have used it, but FW-450 is considerably more phytotoxic. Further experiments with Ethrel and other chemicals are planned.

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APOMIXIS SCREENING

G. A. Smith and R. J. Hecker

Several thousand plants from 35 different source populations have been screened for apomictic behavior, as described in 1969 (Sugarbeet Research, 1969 Report).

We have found several lines which are currently in the third cycle of screening. These lines are being subjected to further controlled pollination and then will be examined critically by floral emasculation and embryo-sac analyses. In addition to the germ plasm from Ft. Collins, we have screened ten Michigan numbers submitted by Dr. George Hogaboam. Of these ten, described as O₂ clone sublines, two are currently in the second cycle of screening.

Generally, plants which have been screened are from heterogenous populations or from inbred populations which show unusual vigor and uniformity.

We would take this opportunity to solicit for screening any material which has shown unusual uniformity or supposed inbred material which has shown unusual vigor.

THE USE OF MITOCHONDRIAL COMPLEMENTATION AS A BREEDING TOOL

G. A. Smith, R. J. Hecker and G. W. Maag

It has been demonstrated that mitochondria isolated from heterotic single cross hybrids of maize, wheat and barley exhibit heterosis in terms of oxygen uptake and phosphorylation, while mitochondria from non-heterotic hybrids do not (McDaniel and Sarkissian 1966). It has also been shown that artificial mixture of mitochondria from various unrelated inbred lines of maize, wheat and barley exhibit oxidative and phosphorylative activities which correspond to the activities of mitochondria of hybrids of these lines (Sarkissian and Srivastava 1967; McDaniel and Sarkissian 1968). This phenomenon has been called mitochondrial complementation (McDaniel and Sarkissian 1966). Evidence of this same phenomenon has also been reported in mung bean. There is good reason to suspect that mitochondrial complementation exists in sugarbeet. Mitochondrial complementation is a new idea, having first been reported in 1966 and as such presents many unanswered questions. On the other hand, the use of complementation as a useful breeding tool in sugarbeet to identify good combining lines and top yielding hybrid combinations appears feasible, and has such great potential that we, as sugarbeet breeders, would be remiss by not thoroughly investigating it as a breeding tool. The method has the potential of relegating to the laboratory the identification of high combining genotypes and those which complement each other in hybrid combinations, necessitating the final testing in the field of only the most promising hybrid combinations.

We have begun work to determine the correct mitochondrial extraction procedures in sugarbeet. Basically, the problem involves extraction of mitochondria from young seedlings without denaturing the mitochondria. The mitochondria are extracted by centrifugation techniques and placed in a reaction buffer mixture. The buffer mixture containing mitochondria is then placed in a closed chamber in a water bath assembly. After addition of a substrate and ADP, change in oxygen consumption is measured with a biological oxygen monitor (Yellow Springs Instrument Co.), utilizing a Clark-type platinum silver electrode.

We are currently developing techniques in wheat similar to recently reported techniques in wheat. Mitochondrial activity is measured at 27° C in a reaction mixture containing alpha-ketoglutarate as the substrate and adenosine diphosphate as the activator. We will use similar techniques on sugarbeet. We are now extracting mitochondria from the shoot tips of 2 to 3-day-old wheat seedlings grown in the dark. In sugarbeet our initial extractions will be from the hypocotyl and cotyledons since it is imperative that a region of high enzymatic activity be used.

The extraction of mitochondria from young seedlings and the test of activity and complementation is relatively rapid. Consequently, large numbers of genotypes could be screened.

NITROGEN INVENTORY STUDY OF SUGARBEET THIN AND PRESSED JUICE INCLUDING PERCENT OF INDIVIDUAL AMINO ACIDS

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Introduction

Sugarbeet quality is a general term intended to describe the relative processing characteristics of beets or the ease and completeness of sucrose recovery from the raw product. Any component that interferes with sucrose recovery is considered undesirable. Quality assessment is usually determined on second carbonation factory juice or its equivalent "phosphated thin juice" as used in our laboratory. Some component factors are known to be more deleterious than others in sucrose crystallization. Nitrogen compounds, especially amino-nitrogen compounds, rank high in their melassigenic effect. It is generally believed that glutamine and its related compounds, glutamic acid and PCA (pyrrolidone carboxylic acid), have greater total effect upon crystallization than all the other amino-nitrogen compounds combined because of their relatively high concentration in the thin juice. The two amides, glutamine and asparagine, probably have a double effect. Not only do they rank high in melassigenic effect, but during processing when the amides convert to their respective amino acids or related alpha keto acids they cause processing difficulties through lowering of buffering capacity and lowering of alkalinity of the juice. This results in less efficient deliming.

This experiment is essentially a nitrogen inventory study of thin juice with emphasis on quantitative determination of individual free amino acids. Other nitrogen components are included in the study, along with some cations and anions. Some pressed juice components will also be determined. Additional work is being done on this study; therefore this report will be on the completed portion of the experiment only.

Materials and Methods

One population, GW 359-52R, grown at 3 nitrogen fertility levels with 6 replications, was used in this experiment. GW 359-52R is an open-pollinated former commercial multigerm variety adapted to the Colorado plains. Normally it has high yield, relatively high sucrose and thin juice purity. The 3 nitrogen treatments were 0 pounds, 125 pounds (preplant), and 250 pounds (125 lbs preplant, 125 lbs side-dressed after thinning). There was apparently considerable residual nitrogen in the experimental area since the 0 nitrogen treatment did not show a severe nitrogen deficiency.

We determined root weight and sucrose content on the roots from which we later extracted pressed juice and prepared phosphated thin juice. Percent apparent purity and recoverable sucrose were also determined. The phosphated

thin juice, according to Carruthers and Oldfield, is equivalent to factory second carbonation juice, which receives no further purification. Therefore, the processor must contend with all the remaining impurities in the extraction and refining process.

Thin juice from each of the 6 replications and 3 nitrogen fertility levels (18 samples) was analyzed for individual free amino acids, plus amides and ammonia, using a Technicon Amino Acid Analyzer. To find the amount of the amides plus PCA present, we hydrolyzed the 18 samples of thin juice and again analyzed for the free amino acids. The amides, glutamine and asparagine, were converted to their respective amino acids during the hydrolyzation. The PCA is not ninhydrin positive and therefore does not produce a peak on the amino acid chromatogram, but during hydrolyzation it, too, is converted to glutamic acid. Therefore the glutamic acid peak on the chromatogram from the hydrolyzed thin juice represents the original glutamic acid plus that converted from glutamine and PCA. Ammonia is ninhydrin positive and therefore the ammonia present in a sample is measured accurately during amino acid analyzer analyses. We also determined total nitrogen, nitrate nitrogen, betaine nitrogen, amino nitrogen, sodium, and potassium in the thin juice. In addition, we plan to analyze the thin juice for other possible nitrogen components such as purines and pyrimidines and some additional non-nitrogen constituents.

We analyzed the 18 pressed juice samples using the amino acid analyzer after first deproteinizing the samples with sulfosalicylic acid (0.1 g per 1.0 ml pressed juice). From this analysis we determined the relative amount of the individual amino acids in the pressed juice compared to those in the thin juice.

Results and Discussion

Table 1 gives the means for 6 replications for plot weight (kg per plot), percent sucrose, percent apparent purity and recoverable sucrose (kg per plot) for each of the 3 nitrogen fertility levels.

Table 1. GW 359-52R plot and thin juice character means for each of 3 nitrogen fertility treatments.

Nitrogen treatment	Plot weight (kg/plot)	% sucrose	% app. purity	Recov. sucrose (kg/plot)
0 lbs/A	17.85	15.97	95.73	2.59
125 lbs/A	20.59	14.12	94.06	2.55
250 lbs/A	19.16	13.53	91.80	2.15

Percent sucrose and apparent purity decreased as the nitrogen fertility level increased. The 125 pound nitrogen fertility level produced the greatest plot weight; however, because of the higher sucrose and apparent purity at 0 lbs nitrogen, recoverable sucrose was slightly higher at the low nitrogen treatment.

Twenty-one free amino acids plus 2 amides were identified in the thin juice and quantitatively determined. The known amino acids and amides are: aspartic (asp), threonine (thr), serine (ser), glutamine (glu-NH₂), asparagine (asp-NH₂), glutamic (glu), proline (pro), glycine (gly), alanine (ala), valine (val), cystine (cys-s-s-cys), methionine (met), isoleucine (ile), leucine (leu), 3,4-dihydroxyphenylalanine (dopa), tyrosine (tyr), phenylalanine (phe), gamma-aminobutyric acid (gaba), ornithine (orn), lysine (lys), histidine (his), tryptophan (try), and arginine (arg). Also present are several unidentified amino acids. We believe some of these unknowns to be citrulline, alpha aminoadipic acid, alpha aminoisobutyric acid, pipecolic acid, and isovaline. Additional work on identification of these unknowns is being done.

Table 2 gives the amino acid means (6 replications) in micromoles per 100 milliliters ($\mu\text{M}/100\text{ml}$) at refractive dry substance of 10 (RDS 10) for each known amino acid and the percent that each was of the total in the thin juice before and after hydrolyzation for each of the 3 nitrogen treatments. The serine value in the unhydrolyzed samples includes the two amides, asparagine and glutamine. In thin juice and pressed juice this value is principally glutamine, with asparagine usually the smallest quantity of the three. Serine, glutamine, and asparagine are eluted on the amino acid chromatogram as occluded peaks (peaks not separated) at the optimum conditions of temperature, pH, and buffer concentration for best peak elution of the other amino acids present in the juices. This occluded peak is measured as serine because the Technicon Amino Acid standard solution used for our standards is composed of 18 of the most common amino acids. Serine is included in this standard as the amino acid eluted at that position on the chromatogram. The amides are not included because of the difficulty of separation. Because of this, the serine quantity reported in unhydrolyzed samples is not accurate, since it does represent the combined amount of the three occluded peaks. When the sample is hydrolyzed the amides are converted to their respective amino acids so the value for serine in the hydrolyzed juice gives the true serine content. The glutamic acid content of the hydrolyzed juice is significantly more than in the unhydrolyzed samples because it shows the original glutamic acid plus that produced from the hydrolysis of the glutamine and the PCA during hydrolysis. The asparagine present in the unhydrolyzed thin juice was converted to aspartic acid during hydrolysis. The increase in the amount of aspartic acid in the hydrolyzed juice over what was present in the unhydrolyzed juice is due to this.

Most amino acids show an increase with each increase in nitrogen fertility. It is interesting to note, however, that the percent of each amino acid remains almost the same. There are a few exceptions to this. Threonine showed a percentage increase at the 250 pound nitrogen treatment in the unhydrolyzed juice. Tyrosine seems to

Table 2. GW 359-52R thin juice amino acid means for each of 3 N treatments ($\mu\text{M}/100\text{ml}$, RDS 10), before and after hydrolyzation, and percent each is of total known amino acids.

Amino Acids	Thin juice									
	Unhydrolyzed					Hydrolyzed				
	0 lbs N	125 lbs N	250 lbs N	0 lbs N	125 lbs N	250 lbs N	0 lbs N	125 lbs N	250 lbs N	
	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	$\mu\text{M}/100\text{ ml}$	%
ASP	77.3	13.0	109.6	12.4	138.6	12.3	131.8	154.2	219.6	12.2
THR	16.6	2.8	17.4	2.0	55.6	4.9	12.4	14.8	21.4	1.2
SER	136.1*	22.9*	211.6*	23.9*	255.9*	22.7*	47.9	60.3	87.8	4.9
GLU	142.7	24.0	194.8	22.0	230.1	20.4	599.0	803.7	1047.9	58.2
PRO	14.9	2.5	21.3	2.4	21.0	1.9	occ.**	occ.	occ.	occ.
GLY	7.2	1.2	11.1	1.3	15.9	1.4	23.6	26.0	36.8	2.0
ALA	23.7	4.0	42.9	4.8	58.5	5.2	28.0	39.4	59.6	3.3
VAL	16.8	2.8	27.2	3.1	35.0	3.1	18.0	25.2	34.6	1.9
CYS	1.2	0.2	1.2	0.1	1.7	0.2	None	None	None	None
MET	3.8	0.6	5.6	0.6	6.9	0.6	4.1	5.5	7.7	0.4
ILEU	30.7	5.2	45.0	5.1	56.3	5.0	32.4	42.1	57.0	3.2
LEU	26.1	4.4	40.0	4.5	53.6	4.8	29.6	40.4	56.3	3.1
Dopa	None	None	None	None	None	None	None	None	None	None
TYR	19.8	3.3	46.3	5.2	66.0	5.8	20.8	44.5	68.3	3.8
PHE	2.9	0.5	3.8	0.4	3.6	0.3	4.0	4.2	4.8	0.3
GABA	68.6	11.5	85.0	9.6	101.3	9.0	62.1	67.3	78.5	4.4
ORN	0.4	0.1	0.4	0.0***	0.6	0.0***	1.6	2.5	3.0	0.2
LYS	3.9	0.6	5.0	0.6	6.4	0.6	4.1	5.0	6.8	0.4
HIS	2.6	0.4	3.8	0.4	5.0	0.4	1.6	1.6	1.6	0.1
TRY	4.9	0.8	6.6	0.8	8.2	0.7	5.0	11.3	7.7	0.4
ARG	4.0	0.7	7.3	0.8	8.3	0.7	None	None	None	None

* Includes asparagine and glutamine

** Occluded

*** Less than 0.05%

respond more to increased nitrogen fertility, both in unhydrolyzed and hydrolyzed samples, than any other amino acid. Proline and gamma-aminobutyric acid (gaba) showed some percentage decrease with nitrogen increase. Proline could not be determined in the hydrolyzed samples. The proline peak is eluted immediately after glutamic acid and was partially occluded to the very large glutamic acid peak. The arginine, present in the unhydrolyzed juice, is apparently converted to ornithine during hydrolysis. Glutamic acid, in the unhydrolyzed thin juice, ranges from 24 percent at 0 pounds of nitrogen down to 20.4 percent at 250 pounds of nitrogen. In the hydrolyzed juice it has increased to 58-59 percent due to the glutamine and PCA conversion. Aspartic acid quantitatively increased in the hydrolyzed thin juice compared to the unhydrolyzed, but the percentage remained almost the same. Gaba, the decarboxylation product of glutamic acid, also showed a smaller percentage in the hydrolyzed juice.

Table 3. GW 359-52R, pressed juice amino acid means for each of 3N treatments ($\mu\text{M}/100\text{ ml}$) and percent each is of total known amino acids.

Amino Acids	0 lbs N		125 lbs N		250 lbs N	
	$\mu\text{M}/100\text{ ml}$	%	$\mu\text{M}/100\text{ ml}$	%	$\mu\text{M}/100\text{ ml}$	%
ASP	197.8	17.6	239.4	16.4	285.1	16.0
THR	22.0	2.0	25.6	1.8	occ.*	occ.*
SER**	311.6	27.8	441.9	30.3	578.3	32.4
GLU	215.3	19.2	270.7	18.6	309.9	17.4
PRO	26.5	2.4	occ.	occ.	occ.	occ.
GLY	7.7	0.7	11.0	0.8	15.8	0.9
ALA	38.0	3.4	58.9	4.0	82.7	4.6
VAL	24.6	2.2	36.1	2.5	47.3	2.6
CYS	None	None	None	None	None	None
MET	5.1	0.4	7.4	0.5	9.8	0.6
ILE	46.4	4.1	61.6	4.2	79.6	4.5
LEU	40.4	3.6	58.1	4.0	76.5	4.3
Dopa	9.9	0.9	14.0	1.0	16.5	0.9
TYR	29.7	2.6	64.8	4.4	96.8	5.4
PHE	3.0	0.3	3.6	0.2	4.5	0.2
GABA	115.1	10.3	127.5	8.7	135.8	7.6
ORN	0.3	0.0***	0.3	0.0***	0.3	0.0***
LYS	6.1	0.6	7.3	0.5	9.4	0.5
HIS	6.0	0.5	8.8	0.6	11.0	0.6
TRY	9.0	0.8	10.9	0.8	13.4	0.8
ARG	6.1	0.6	10.4	0.7	12.8	0.7

* Occluded

** Includes asparagine and glutamine

*** Less than 0.05%

The same amino acids were present in the pressed juice (Table 3) as were found in the thin juice, with two exceptions. A small amount of cystine was found only in the thin juice samples, while some 3,4-dihydroxyphenylalanine (dopa) was present only in the pressed juice samples. There was a difference also in the percentage of some amino acids in the pressed juice from what was found in the thin juice. As in the unhydrolyzed thin juice samples, the serine value in the pressed juice represents a combination of the occluded peaks of serine, glutamine, and asparagine (mainly glutamine). Also the proline peak was occluded to the large glutamic acid peak at the 125 and 250 pound nitrogen fertility levels in the pressed juice analyses. We have no results for hydrolyzed pressed juice which would give the increased value for glutamic acid that would result from conversion of glutamine and PCA to glutamic acid during hydrolysis. It would also give the amount of aspartic acid which would represent the original aspartic acid plus any hydrolyzed asparagine. Results from a small survey comparison study that we made earlier on other hydrolyzed and unhydrolyzed pressed juice samples showed almost a ten-fold increase in the quantity of glutamic acid after hydrolysis but a relatively small increase in aspartic acid. The serine-glutamine-asparagine value decreased after hydrolysis in those samples to about one-seventh of its original value; apparently most of the decrease was due to glutamine conversion and very little due to asparagine conversion. Whether or not our GW 359-52R samples would give similar results we do not know. The percentage of aspartic acid in the GW 359-52R unhydrolyzed pressed juice ranges from 17.6 percent at 0 pounds nitrogen to 16.0 percent in the 250 pound nitrogen treatment, compared to the range of 13.0 to 12.3 percent in the corresponding unhydrolyzed thin juice samples. Glutamic acid in the pressed juice ranges from 19.2 percent in the low nitrogen treatment down to 17.4 percent in the high nitrogen treatment samples, while the corresponding unhydrolyzed thin juice samples show a range from 24.0 percent down to 20.4 percent glutamic acid. This difference is probably due to some glutamine being converted to glutamic acid during the preparation of the phosphated thin juice. The percentage of threonine and glycine was also higher in the thin juice than in the pressed juice, as well as gamma-aminobutyric acid (the decarboxylation product of glutamic acid).

Table 4. GW 359-52R thin juice component means (mg/100 ml, RDS 10) for each of 3 N treatments.

N treatment	mg/100 ml, RDS 10						
	Kjeldahl total N*	Amino N	$\text{NO}_3^- \text{N}$	$\text{NH}_4^+ \text{N}$	Betaine N	Na	K
0 lbs N	32.83	14.78	0.97	2.28	14.53	22.62	61.98
125 lbs N	45.16	22.89	2.48	3.84	15.38	45.20	70.23
250 lbs N	58.54	28.82	3.36	4.53	15.10	51.59	72.87

* Kjeldahl total N includes $\text{NO}_3^- \text{N}$.

A comparison of the means for the 3 nitrogen fertility level thin juice components (Table 4) of Kjeldahl total nitrogen (which includes nitrate nitrogen), amino nitrogen, nitrate nitrogen ($\text{NO}_3^- \text{N}$), ammonium nitrogen ($\text{NH}_4^+ \text{N}$), betaine nitrogen, sodium (Na), and potassium (K) show an increase in milligrams per 100 ml (mg/100 ml) of thin juice in each component as the nitrogen treatment increases, except for betaine nitrogen. There is a greater increase between the 0 and 125 pound treatment than between the 125 and 250 pound treatment. Betaine nitrogen shows a slight decrease in the 250 pound over the 125 pound treatment. The ratio of K to Na at 0 pounds nitrogen is almost three to one but the ratio is considerably less at the higher nitrogen treatments.

The amount of thin juice nitrogen due to each nitrogen source is given in Table 5. The Kjeldahl total nitrogen was determined by the method which includes nitrate nitrogen. In addition, separate determinations were made for nitrate nitrogen, ammonium nitrogen (determined during the amino acid analyses) and betaine nitrogen. The amino acid nitrogen was calculated and totalled from the micromoles per 100 ml of each amino acid given in Tables 2 and 3, using the percent nitrogen in each mole weight. Included in this total is an estimated amount of nitrogen due to the occluded serine-glutamine-asparagine peaks in the unhydrolyzed samples. (In the hydrolyzed samples this peak is only serine, because the glutamine and asparagine have been converted). We used the ratio of one part serine, two parts glutamine and five-tenths (0.5) part asparagine. It is necessary to do this because glutamine and asparagine contain two gram-atoms of nitrogen per mole weight while serine contains one gram-atom nitrogen per mole weight. The ratio 1:2:0.5 is an approximation of the ratio in which the three exist in the phosphated thin juice. The amino acid nitrogen in the unhydrolyzed thin juice is less at each nitrogen fertility level than in the hydrolyzed thin juice because during hydrolyzation the amides and PCA were converted to the amino acids. PCA is not ninhydrin positive and therefore did not show on the amino acid chromatograms in the unhydrolyzed samples.

Amino nitrogen in unhydrolyzed thin juice was also determined separately by a colorimetric method and the values are given at the bottom of Table 5. The calculated amino acid nitrogen is less than the colorimetric amino nitrogen. This is because the nitrogen in the unidentified amino acids is not included in the calculated amino acid nitrogen. We cannot quantitatively calculate unknown peaks without standards. The amino nitrogen also includes the ammonium nitrogen present. When we subtract each ammonium nitrogen value from the corresponding colorimetrically determined amino nitrogen value we obtain 12.50, 19.05, and 24.29 mg N per 100 ml due to amino N alone for the 0, 125, and 250 pound nitrogen treatment, respectively. Each of these values differs some from the corresponding amino acid nitrogen value. This difference is probably due to the nitrogen in unidentified amino acids or to analogues which are ninhydrin positive.

Table 5. Thin juice nitrogen means (mg/100 ml, RDS 10) from individual N sources, 3 N fertility levels.

N Source	mg/100 ml, RDS 10					
	0 lbs N		125 lbs N		250 lbs N	
	Unhyd ^{1/}	Hyd ^{2/}	Unhyd	Hyd	Unhyd	Hyd
Kjeldahl total N*	32.83		45.16		58.54	
NO ₃ ⁻ N	0.97		2.48		3.36	
NH ₄ ⁺ N	2.28	0.65	3.84	0.62	4.53	0.72
Betaine	14.53		15.38		15.10	
Amino Acid N	10.05	14.54	14.88	19.18	18.79	25.50
Sum (N sources)	27.83	30.69	36.58	37.66	41.78	44.68
Amino N**	14.78		22.89		28.82	

^{1/} Unhydrolyzed

^{2/} Hydrolyzed

* Includes NO₃⁻N

** Amino N determined colorimetrically

The sum of the nitrogen values in the unhydrolyzed thin juice (Table 5) from the 4 nitrogen sources (NO₃⁻N, NH₄⁺N, betaine N, and amino acid N) is less for each N fertility level than the corresponding Kjeldahl total nitrogen value. Again this difference is partially due to the PCA nitrogen and the nitrogen from the unidentified amino acids. Also the estimated amount of nitrogen due to the glutamine and asparagine may be low. The nitrogen source sum which results from using the NH₄⁺N and the amino acid nitrogen values from the hydrolyzed thin juice samples in place of the equivalent values from the unhydrolyzed thin juice samples is higher because the amides and PCA have been converted to aspartic or glutamic acids and now the nitrogen due to them can be accurately calculated. However, an additional loss of nitrogen is involved in the hydrolyzed samples due to loss of ammonia gas during the basic hydrolysis. Most of the original ammonium nitrogen is lost in this way, plus the ammonia gas given off from the deamidation of the amides during the hydrolysis reaction. Nitrogen from other undetermined nitrogen sources may also be a factor in the higher Kjeldahl total nitrogen. Additional work is planned on other possible nitrogen components such as organic acids, nucleosides, purines, and pyrimidines.

In the unhydrolyzed thin juice betaine nitrogen ranks highest, but in the hydrolyzed thin juice the amino acid nitrogen ranks highest. This indicates that if the total amino acid nitrogen, plus nitrogen from the amides and PCA, as well as nitrogen from unidentified amino acids, could be totalled in the unhydrolyzed thin juice, it would rank higher than the betaine nitrogen and probably higher than all other nitrogen combined, including betaine nitrogen.

With additional work we hope that the remainder of the thin juice nitrogen can be identified. It would be interesting also to know if there is a significant variation in the percent of the individual amino acids in the thin juice from different sugarbeet varieties. If so, is the melassigenic quality of the thin juice affected? Only further investigation will answer these questions.

SUGARBEET LEAF AMINO ACIDS IN DIFFERENT SECTIONS OF THE LEAF AND IN DIFFERENT AGED LEAVES

G. W. Maag, R. J. Hecker and P. A. Whitaker

During the past three years the Sugarbeet Investigations Research team at Fort Collins, Colorado has been engaged in a study of the free amino acids found in sugarbeets and their relation to population genetics, Cercospora leaf spot disease resistance, and thin juice quality components. Thin juice, according to Carruthers and Oldfield, is equivalent to factory second carbonation juice. We have determined the amino acids in thin juice, pressed juice, fresh root, and fresh leaf samples. Since no previous amino acid studies have been made on sugarbeet materials using an amino acid analyzer, it was necessary to devise sampling and sample preparation techniques.

In Cercospora disease resistant studies we were especially interested in the leaf amino acids before and after infection in leaf spot resistant and susceptible varieties. To obtain representative sampling we select one leaf from each plant in each replication. When several sugarbeet varieties with three or more replications are used in a study it is inconvenient to use the whole leaf in the sample preparation because of bulk. The number of samples involved must also be considered because only two samples can be analyzed in a 24-hour period on our two-column amino acid analyzer.

The purpose of this survey study was to determine the free amino acids in different aged sugarbeet leaves and in different sections of the leaf to aid us in selecting the best sampling technique. We also determined the best liquid grinding medium to use and the best proportion of leaf weight to volume of liquid medium in sample preparation.

Materials and Methods

The materials used for this experiment were grown under irrigation at the Colorado State University Research Center, at Fort Collins, Colorado.

Four populations covering a wide range of Cercospora leaf spot resistance were planted in a randomized block design with four replications. The plants for this survey study were grown under disease-free conditions and were harvested about mid-summer. The populations were:

1. US 201, highly leaf spot resistant (LSR), relatively heterogeneous
2. GWI-29, leaf spot resistant (LSR), inbred
3. R & G Pioneer, leaf spot susceptible (LSS), heterogeneous
4. 52-407, leaf spot susceptible (LSS), inbred

One leaf from each plant in each replication of each of the four varieties was harvested for the individual amino acid study of three sections of the leaf--base, mid, and tip. The leaves selected were intermediate between the small young leaves and the largest old leaves which show some signs of senility. At the plant growth stage on harvest day the leaf selected represented the most typical leaf on each plant. Usually four such leaves are present and the best of the four was selected. The leaves from each replication were stacked carefully, tip to tip and petiole to petiole, and placed in a plastic bag with proper labeling. The amino acid samples were prepared in the laboratory immediately after harvest.

Each replication of the stacked medium-aged leaves was carefully removed from the plastic bag and cut transversely into three sections--base, mid, and tip. The section was weighed carefully and placed in a Waring blender. We added 4 ml of 10 percent sulfosalicylic acid solution (w/v with glass distilled water) for each gram of fresh leaf and ground at high speed for 5 minutes. Previously, we had tested different proportionate amounts of different grinding media and we selected 4 ml of 10 percent sulfosalicylic acid per gram of fresh leaf as the media which best deproteinizes the leaf sample and dissolves the free amino acids present in the sample with the dilution factor kept to a minimum. Glass distilled or high quality de-ionized water must be used for preparation of all samples and solutions which pass through the analyzer column resin beads because certain metallic ions, such as copper or zinc, strongly adhere to the sulfonated resin beads and cause appreciable loss in sensitivity and may completely destroy the elution pattern. After the 5-minute grinding, the slurry is poured into a clean container and allowed to set until the liquid layer separates at the bottom of the mixture. An aliquot (10-15 ml) of the

liquid is centrifuged at about 15,000 rpm for 10 minutes. To reduce the number of analyses for this study, the replications from each population were pooled by pipetting 5 ml of each replication sample into a clean vial. The pooled sample was adjusted to a pH 2.0 with 40 percent NaOH and stored frozen until analysis could be made.

The samples for the amino acid study of different aged leaves were prepared by the same method. Three leaves were selected from each plant of each replication--one old leaf, one medium-aged leaf (equivalent to those used above) and one young, partially expanded leaf. The leaves were stacked and bagged as before and the samples were prepared in the laboratory immediately after harvest. Only the mid-transverse section from each replication sample was used. The sample was weighed carefully; the calculated amount of 10 percent sulfosalicylic acid was added and the samples were prepared, pooled by population, taken to a pH 2.0, and stored frozen until analysis.

Results and Discussion

Twenty-one free amino acids and two amides were identified and quantitatively determined in the fresh leaf samples. Several unknown amino acids were also present. Identification of some unknowns, included in the above twenty-one amino acids, has been made. Five of the other unknowns we believe to be citrulline, alpha-aminoadipic acid, alpha-aminoisobutyric acid, pipecolic acid, and iso-valine. Work on identification is still in process. The amino acid, serine, and two amides, glutamine and asparagine, are eluted on the chromatograms as an occluded peak (peaks not separated). This occluded peak area was calculated as one peak using serine as the standard. In leaves, this occluded peak is principally serine. In thin and pressed juice and fresh root samples this peak is principally glutamine with serine and asparagine existing in varying amounts. Threonine is sometimes also occluded to the larger serine-glutamine-asparagine peak and proline is sometimes difficult to separate from the larger glutamic acid peak which elutes on the chromatogram just before proline. The known amino acids and amides were: aspartic acid (asp), threonine (thr), serine (ser), glutamine (glu-NH₂), asparagine (asp-NH₂), glutamic acid (glu), proline (pro), glycine (gly), alanine (ala), valine (val), cystine (cys-s-s-cys), methionine (met), isoleucine (ileu), leucine (leu), 3,4-dihydroxyphenylalanine (dopa), tyrosine (tyr), phenylalanine (phe), gamma-amino butyric acid (gaba), ornithine (orn), lysine (lys), histidine (his), tryptophan (try), and arginine (arg).

Table 1 gives the micromoles (μ M) of free amino acids per 100 grams fresh leaf for the three transverse sections for each population. Glutamic acid was present in the greatest amount in all populations and in all three sections. The tip section contained the greatest amount of glutamic acid in all varieties with the susceptible heterogeneous

variety, R & G Pioneer, ranking highest and the susceptible inbred, 52-407, ranking second highest. The two heterogeneous populations showed slightly more in the mid-section part than in the base, while the two inbred varieties contained more in the base than in the mid-section. Aspartic acid ranked second in quantity in all varieties; the tip section contained the most aspartic acid, while the mid-section was second (in all varieties except GWI-29, in which the mid and base sections contained practically the same amount). The combination of serine-glutamine-asparagine (mainly serine in leaves) and gamma-aminobutyric acid (gaba) exist in approximately the same amount in each population, usually with the greatest amount in the tip section and the smallest amount in the base section, except for gaba, which was found in the smallest amount in the mid-section in each variety. US 201 contained the largest amount of gaba in the base and tip sections. The other amino acids, when ranked by decreasing quantity, were: alanine, proline, threonine, valine, glycine and tyrosine, with all others being present in only minute quantities. Usually the tip section contained more of each of these amino acids than the mid and base sections. The two heterogeneous varieties contained more tyrosine than the inbred varieties.

Table 2 shows the amounts of the amino acids in the different aged leaves from the same four populations. Again glutamic acid is the predominant amino acid, with aspartic, serine-glutamine-asparagine (mainly serine), gaba, alanine, proline, and threonine next in order of importance. The two inbred varieties showed the greatest amount of glutamic in the medium-aged leaves while the two heterogeneous populations showed more in the young and old leaves. This was especially true of the variety US 201. The LSS inbred, 52-407, also showed more aspartic in the middle-aged leaves while the two heterogeneous varieties showed the least amount of aspartic in the middle-aged leaves. In fact, the middle-aged leaves of US 201 showed the least amount of each amino acid except for proline which was present in the largest amount in the US 201 middle-aged leaves. Proline was also present in the greatest amount in the middle-aged leaves of GWI-29 and 52-407, but ranked first in the old leaves of R & G Pioneer.

Conclusion

The amino acid content of different sections of the leaves and different aged leaves showed considerable variation. Sometimes similar patterns were evident in the two heterogeneous varieties or the two inbred lines. In one or two instances there appeared to be a difference in the amount of certain amino acids when the LSR and LSS populations were compared. The purpose of this experiment was to decide the best representative sampling technique. Based upon the results, we have decided that the medium-aged leaf is the most representative leaf on the plant and that the mid-section of the leaf is the most representative part of the leaf. It is advisable that the same person(s) do the sampling each time.

Table 1. Amino acids ($\mu\text{M}/100\text{g}$) in base, mid, and tip sections of fresh leaves (four populations).

Amino acids $\mu\text{M}/100\text{g}$	US 201			GWI-29			R & G Pioneer			52-407		
	Base	Mid	Tip	Base	Mid	Tip	Base	Mid	Tip	Base	Mid	Tip
ASP	119.1	200.4	283.9	195.8	194.5	261.0	178.0	205.5	302.4	157.3	207.6	290.1
THR	12.8	15.2	11.2	15.6	13.3	9.9	13.4	19.4	16.1	12.3	18.0	22.2
SER*	94.5	117.4	119.5	96.4	110.4	85.4	69.2	105.5	98.1	65.6	92.6	111.4
GLU	220.2	263.9	389.7	356.8	298.6	410.3	313.8	325.3	464.8	283.1	241.5	433.2
PRO	21.2	27.8	occ.**	38.6	21.9	occ.	23.3	19.9	occ.	22.8	18.0	39.6
GLY	6.6	8.2	10.6	7.1	10.2	13.0	4.4	7.9	10.2	3.2	6.8	7.3
ALA	72.9	66.0	98.6	56.2	52.8	41.6	37.3	61.3	66.7	21.0	44.7	49.0
VAL	13.4	14.8	25.2	11.4	13.0	13.4	8.6	13.9	23.5	5.6	10.4	14.4
CYS	2.2	Trace	6.7	3.1	Trace	5.0	2.5	Trace	11.7	1.5	Trace	4.5
MET	Trace	Trace	2.6	Trace	Trace	Trace	Trace	Trace	2.4	Trace	Trace	2.2
ILEU	7.3	6.2	13.0	7.3	5.9	8.2	6.7	7.5	14.9	4.1	6.0	9.5
LEU	9.7	6.2	7.6	9.7	7.5	7.6	6.9	5.1	8.2	5.7	5.6	8.8
Dopa	1.3	Trace	1.5	Trace	Trace	Trace	Trace	Trace	Trace	1.5	Trace	2.2
TYR	9.8	10.1	18.4	8.7	8.7	10.9	9.6	11.5	18.5	5.6	6.8	10.9
PHE	4.9	8.6	7.5	7.0	7.9	6.6	5.4	7.1	6.8	3.4	5.6	6.8
GABA	136.3	60.7	140.9	114.3	38.4	60.0	67.5	54.9	91.0	72.6	55.1	121.5
ORN	Trace	Trace	Trace	1.4	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
LYS	4.1	2.7	3.6	3.7	2.8	3.5	2.4	2.0	2.9	2.1	3.2	2.7
HIS	2.4	2.7	2.5	2.1	Trace	1.6	2.4	2.1	2.0	1.4	2.0	2.3
TRY	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	1.6
ARG	3.6	1.7	2.4	1.4	Trace	1.0	1.4	1.2	1.6	2.6	1.7	1.5

* Includes glutamine and asparagine

** Occluded peaks

Table 2. Amino acids ($\mu\text{M}/100\text{g}$) in different aged leaves--young, medium, and old (four populations).

Amino acids $\mu\text{M}/100\text{g}$	US 201			GWI-29			R & G Pioneer			52-407		
	Young	Medium	Old	Young	Medium	Old	Young	Medium	Old	Young	Medium	Old
ASP	182.9	111.3	221.7	81.8	150.5	158.4	134.2	117.6	189.5	135.6	216.5	154.5
THR	15.7	11.8	29.9	17.2	18.8	25.9	17.9	13.4	21.1	occ.*	35.0	19.0
SER**	132.4	55.2	66.6	112.2	100.4	67.4	94.8	48.6	65.0	occ.	112.9	62.6
GLU	309.1	192.3	271.9	218.5	314.3	222.2	233.1	231.0	257.6	240.7	329.3	217.0
PRO	29.9	43.7	19.8	27.3	86.7	40.0	18.4	22.5	27.5	46.5	63.0	35.7
GLY	6.1	3.0	5.6	4.9	3.9	3.8	4.9	3.2	2.8	4.5	3.9	4.2
ALA	62.0	38.0	45.9	61.6	53.3	29.5	58.0	41.1	30.1	45.3	39.2	21.1
VAL	13.6	8.3	18.4	11.5	9.4	26.4	12.2	7.7	17.9	14.3	19.8	16.7
CYS	Trace	4.9	10.7	3.6	3.2	3.9	Trace	5.1	6.3	Trace	7.0	6.0
MET	Trace	Trace	1.6	Trace	2.8	Trace	Trace	Trace	1.5	2.2	3.4	2.7
ILEU	9.7	5.1	11.2	9.8	6.8	13.4	53.4	7.2	10.0	14.0	11.6	8.6
LEU	9.0	8.1	17.1	13.8	9.7	34.6	15.0	7.0	20.0	18.3	16.0	13.7
Dopa	3.1	1.7	Trace	1.2	Trace	1.1	1.5	Trace	Trace	1.6	1.9	1.5
TYR	15.8	5.0	8.3	10.9	4.5	9.8	27.9	4.2	8.1	9.7	8.9	7.4
PHE	4.7	4.5	8.7	5.2	6.6	16.0	5.0	4.6	9.4	5.8	12.3	9.6
GABA	69.6	61.4	72.2	127.2	107.6	82.5	82.3	65.1	86.3	83.2	84.8	51.2
ORN	0.8	Trace	Trace	0.7	Trace	Trace	0.8	0.8	Trace	Trace	Trace	Trace
LYS	5.6	5.0	6.4	8.1	5.2	7.4	8.1	4.1	7.0	8.6	8.7	5.3
HIS	17.1	2.4	2.9	4.0	1.4	5.9	83.2	1.5	4.4	25.0	6.8	4.0
TRY	4.2	Trace	3.0	4.3	Trace	5.2	2.3	Trace	3.5	2.4	12.0	5.0
ARG	5.2	2.3	3.3	3.3	2.9	5.3	5.9	2.2	7.0	18.5	30.9	3.4

* Occluded peaks

** Includes glutamine and asparagine

SUGARBEET RESEARCH

1970 Report

Section E

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Buckeye Sugars, Inc.
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Monitor Sugar Division
Northern Ohio Sugar Company
Michigan Agricultural Experiment Station
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North Dakota Agricultural Experiment Station
Red River Valley Sugarbeet Growers Association, Inc.

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CONTENTS

	Page
EVALUATION OF SUGARBEET HYBRIDS by G. J. Hogaboam and R. C. Zielke	
Summary of 6x6 LSQ tests	E3
Nursery evaluation test, Ferden farm	E7
Field tests, Northern Ohio Sugar Company	E8
VARIETAL RESISTANCE TO RHIZOCTONIA by G. J. Hogaboam and C. L. Schneider	E16
BREEDING SUGARBEETS FOR RESISTANCE TO BLACK ROOT AND LEAF SPOT by G. E. Coe	
Progress in improving black root resistance	E19
Progress in improving leaf spot resistance	E19
Breeding for globe-shaped beets	E22
SEED PRODUCTION PROGRAM FOR THE EASTERN AREA by R. C. Zielke . .	E23
POWERED AUGER USED TO DIG HOLES FOR MOTHER ROOTS by R. C. Zielke	E27
SUGARBEET DISEASE INVESTIGATIONS AT EAST LANSING, MICHIGAN IN 1970 by C. L. Schneider	
Testing disease resistance	E28
Chemical control	E30
Biology of root disease fungi	E31
PHYSIOLOGICAL INVESTIGATIONS - 1970 by F. W. Snyder	
Germination and emergence studies	E35
Leaf accretion studies	E36
Enzymes in sugarbeet leaves	E37
Translocation studies	E38
PHYSIOLOGICAL AND HISTOLOGICAL INVESTIGATIONS OF SUGARBEETS by R. M. Cressman	
Diffusion of sugar from sugarbeet tissue	E39
Histological analyses and observations	E47
Storage quality in relation to phosphate fertility	E49
The effect of temperature and depth of planting on germination of sugarbeet seed	E51
SEEDLING DISEASES, RED RIVER VALLEY by W. M. Bugbee	E55
PECTOLYTIC ENZYME PRODUCTION BY SUGARBEET STORAGE ROT ORGANISMS by W. M. Bugbee	E57
RED RIVER VALLEY VARIETY TEST by W. M. Bugbee	E69

EVALUATION OF SUGARBEET HYBRIDS

Prepared by G. J. Hogaboam and R. C. Zielke

The cooperative evaluation program was continued in 1970 with the Farmers & Manufacturers Beet Sugar Association and its member companies as well as with the Great Western Sugar Company, the American Crystal Sugar Company, and Holly Sugar Corporation.

In the past the extraction formulas used in calculating recoverable sugar per ton gave values which were too high when compared with the values obtained in factory operations. Mr. M. G. Frakes, Director of Research, Michigan Sugar Company, has worked out a formula which makes possible the calculation of pounds of sugar going into molasses per ton of beets (MST), the pounds of non-recoverable sugar per ton of beets (NRST), as well as the recoverable white sugar per ton (RWST), and percent of gross sugar recoverable as white sugar (PGSR). This formula can be applied to: fresh harvested beets, average for a campaign, or any particular segment of the campaign by inputting the applicable factors. This formula was programmed for use in the Monroe 1665 calculator¹ by G. J. Hogaboam. With this system the inputs necessary are plot identification, percent sugar by weight in beets, percent RDS by volume of the clear juice, and percent sugar by volume of the clear juice. The calculator then computes the data and outputs the sample card number, the plot identification, percent sugar in beets, percent clear juice purity, the (RWST), the (MST), the (NRST), and the (PGSR).

All individual experiment data were analyzed in indicated units and then the performance and LSD values were calculated as percent of the general mean. The analysis by area had the "location level" effects removed by compositing the data as percent of the general mean. Composite analyses were made for the tests in the Ohio area, for the tests in the Michigan area and then for the average of all the tests. The commercial variety for the 1970 6 x 6 Latin Squares is entry number 3, which is UI(11863 x 12163) x SP6322-0. This variety is very similar in breeding background to SL(129 x 133) x SP6322-0, which has been the commercial in previous years. The extra high quality of the hybrid SP67550-02 x SP6822-0 should be noted. In recoverable white sugar per ton of roots, this hybrid yielded more sugar per ton than the average in all tests and this difference was significant in all but one test. The performance of this hybrid is similar to the results obtained from SP65550-1 x SP6322-0 in the 1968 and 1969 hybrid screening tests. Another hybrid in the 1970 LSQ tests, UI(100363 x 2161) x SP6528-0, continued the good performance given by UI(100363 x 2161) x SP6828-01 in the 1969 tests.

A nursery hybrid evaluation test is reported this year since there were no outstate hybrid evaluations to report. This six replication experiment had single row plots 18' long, however. The coefficient of variability values are comparable to the 6 x 6 Latin Square tests in Michigan and Ohio. This test was conducted by Dr. Richard Zielke.

¹ Mention of a specific machine does not imply its approval to the exclusion of others. It is merely the one used.

1970, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code [@]						LSD 5 % on % G.M.	Actual G.M.		C.V.%
		1	2	3	4	5	6				
Re- cover- able white sugar per acre	11	104.1	111.5	106.0	87.9	105.9	84.7	15.5	4144 lbs		12.85
	12	96.5	111.4	97.1	92.8	102.9	99.4	NS	5822 lbs		15.15
	13	96.1	95.9	94.5	100.9	110.3	102.3	10.6	6274 lbs		8.77
	Ohio Avg	98.9	106.3	99.2	93.9	106.4	95.5	NS	100 %		7.53
	14	101.3	99.8	101.8	100.9	101.3	95.0	NS	9350 lbs		6.71
	16	101.4	109.1	99.2	98.6	95.0	96.7	NS	8191 lbs		8.07
	17*	111.7	110.2	101.9	95.1	94.6	86.5	12.6	7269 lbs		9.52
	18	101.6	98.2	100.9	103.4	100.6	95.2	NS	7953 lbs		5.82
	Mich Avg	104.0	104.3	101.0	99.5	97.9	93.4	7.2	100 %		4.75
	Grand Avg	101.8	105.2	100.2	97.1	101.5	94.3	6.8	100 %		6.18
Roots- Tons/ Acre	11	105.4	110.0	109.0	92.6	99.3	83.7	12.1	17.04 tons		10.01
	12	104.6	107.5	98.6	99.6	95.3	94.5	NS	28.02 tons		12.79
	13	101.6	97.6	98.3	103.7	100.3	98.4	NS	29.68 tons		5.86
	Ohio Avg	103.9	105.0	102.0	98.6	98.3	92.2	NS	100 %		6.01
	14	104.0	100.0	102.8	103.0	95.4	94.8	5.7	40.17 tons		4.74
	16	104.2	105.3	99.6	102.3	89.9	98.6	8.8	32.74 tons		7.34
	17*	107.4	103.7	104.1	103.0	90.4	91.4	12.2	31.10 tons		9.27
	18	103.9	98.1	103.8	102.2	94.9	97.0	5.6	32.91 tons		4.63
	Mich Avg	104.9	101.8	102.6	102.6	92.7	95.5	4.1	100 %		2.70
	Grand Avg	104.4	103.2	102.3	100.9	95.1	94.1	4.8	100 %		4.44
Re- cover- able white sugar per ton of roots	11	98.8	101.4	96.8	95.1	106.5	101.4	5.2	242.7 lbs		4.29
	12	92.1	104.6	97.5	93.3	108.1	104.4	7.8	206.6 lbs		6.47
	13	94.6	98.4	96.1	97.5	109.5	103.9	5.9	211.0 lbs		4.87
	Ohio Avg	95.2	101.4	96.8	95.3	108.0	103.2	4.5	100 %		2.48
	14	97.3	99.7	98.9	97.8	106.2	100.1	5.3	233.0 lbs		4.39
	16	97.3	103.4	99.9	96.0	105.6	97.8	4.4	250.1 lbs		3.66
	17*	104.1	106.1	97.8	92.5	104.7	94.6	5.3	233.9 lbs		4.03
	18	97.7	100.0	97.4	101.1	105.9	97.9	4.3	242.0 lbs		3.61
	Mich Avg	99.1	102.3	98.5	96.9	105.6	97.6	4.3	100 %		2.83
	Grand Avg	97.4	101.9	97.8	96.2	106.6	100.0	3.4	100 %		3.07

1970, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code [@]						LSD 5 % on % G.M.	Actual G.M.		C.V.%
		1	2	3	4	5	6				
% Su- crose	11	98.5	101.3	97.8	95.7	105.7	101.0	4.2	14.71 %		3.46
	12	94.1	103.5	97.7	95.2	105.4	104.0	6.6	13.37 %		5.49
	13	96.0	98.6	96.4	98.6	106.5	103.9	4.4	13.45 %		3.64
	Ohio										
	Avg	96.2	101.1	97.3	96.5	105.9	103.0	3.5	100 %		1.90
	14	98.2	99.5	98.6	99.1	104.4	100.3	NS	14.65 %		3.45
	16	98.2	102.6	99.7	97.2	104.2	98.1	3.3	15.15 %		2.70
	17*	104.1	105.2	97.1	94.1	104.3	95.2	4.9	14.23 %		3.69
	18	98.0	99.0	98.7	101.4	104.2	98.7	3.1	14.88 %		2.57
	Mich										
	Avg	99.6	101.6	98.5	98.0	104.3	98.1	3.8	100 %		2.55
	Grand										
	Avg	98.2	101.4	98.0	97.3	105.0	100.2	2.9	100 %		2.62
% CJ purity	11	100.1	100.0	99.5	99.8	100.3	100.2	NS	94.62 %		0.59
	12	99.2	100.5	100.0	99.1	101.2	100.0	0.9	91.58 %		0.77
	13	99.4	100.0	99.9	99.5	101.4	99.9	1.0	92.26 %		0.83
	Ohio										
	Avg	99.6	100.2	99.8	99.5	101.0	100.0	0.8	100 %		0.42
	14	99.6	100.1	100.2	99.3	100.8	99.9	0.8	92.75 %		0.64
	16	99.5	100.4	100.1	99.4	100.7	99.9	0.7	94.58 %		0.58
	17*	99.9	100.4	100.5	99.2	100.1	99.9	0.7	94.50 %		0.55
	18	99.9	100.6	99.3	99.8	100.8	99.6	0.9	93.82 %		0.76
	Mich										
	Avg	99.7	100.4	100.0	99.4	100.6	99.8	0.5	100 %		0.33
	Grand										
	Avg	99.7	100.3	99.9	99.4	100.8	99.9	0.4	100 %		0.36
Molas- ses sugar /ton of roots	11	96.2	101.1	105.4	99.6	100.4	97.2	NS	25.6 lbs		8.19
	12	102.9	98.5	97.9	105.1	92.1	103.5	NS	35.9 lbs		8.75
	13	103.3	98.8	97.2	104.9	90.2	105.6	10.3	33.2 lbs		8.58
	Ohio										
	Avg	100.8	99.5	100.2	103.2	94.2	102.1	NS	100 %		4.40
	14	103.8	97.8	95.6	107.6	93.5	101.7	8.5	34.1 lbs		7.10
	16	106.3	95.8	98.0	107.0	92.9	99.9	9.6	26.5 lbs		8.00
	17*	106.5	100.0	89.6	106.2	103.8	94.0	11.2	25.1 lbs		8.52
	18	100.3	90.2	108.7	104.6	92.1	104.2	12.4	29.5 lbs		10.26
	Mich										
	Avg	104.2	96.0	98.0	106.4	95.6	100.0	NS	100 %		5.30
	Grand										
	Avg	102.8	97.5	98.9	105.0	95.0	100.9	5.3	100 %		4.81

** & @, see page E6

1970, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code [@]						LSD 5 % on % G.M.	Actual G.M.	C.V.%
		1	2	3	4	5	6			
Non- re- cover- able	11	99.3	100.6	98.9	98.0	102.7	100.5	2.0	25.9 lbs	1.63
	12	97.3	101.6	98.9	97.9	102.5	101.8	3.0	24.8 lbs	2.48
	13	98.2	99.4	98.4	99.4	103.0	101.8	2.0	24.9 lbs	1.65
	Ohio Avg	98.3	100.5	98.7	98.4	102.7	101.4	1.6	100 %	0.85
	sugar /ton	99.2	99.8	99.3	99.6	102.1	100.1	NS	25.9 lbs	1.64
of roots	16	99.1	101.3	99.8	98.6	102.0	99.1	1.6	26.3 lbs	1.31
	17*	101.9	102.4	98.7	97.2	102.0	97.7	2.3	25.5 lbs	1.73
	18	99.1	99.5	99.4	100.7	102.0	99.4	1.5	26.1 lbs	1.23
	Mich Avg	99.8	100.8	99.3	99.0	102.0	99.1	1.8	100 %	1.20
	Grand Avg	99.2	100.7	99.1	98.8	102.3	100.1	1.4	100 %	1.21
% of gross as re- cover- able white sugar	11	100.2	100.1	99.0	99.5	100.8	100.5	NS	82.5 %	1.16
	12	98.1	101.1	99.7	98.0	102.6	100.3	2.0	77.2 %	1.64
	13	98.6	100.0	99.6	98.9	102.9	100.0	2.0	78.3 %	1.70
	Ohio Avg	99.0	100.4	99.4	98.8	102.1	100.3	1.6	100 %	0.85
	14	99.1	100.2	100.4	98.7	101.7	99.8	1.6	79.5 %	1.29
	16	99.1	100.9	100.2	98.7	101.4	99.7	1.4	82.5 %	1.14
	17*	100.1	100.9	100.7	98.3	100.5	99.5	1.3	82.1 %	1.01
	18	99.7	101.1	98.6	99.7	101.6	99.3	1.8	81.3 %	1.45
	Mich Avg	99.5	100.8	100.0	98.9	101.3	99.6	1.0	100 %	0.63
	Grand Avg	99.3	100.6	99.7	98.8	101.6	99.9	0.8	100 %	0.74
Beets per 100' of row	11	100.2	100.6	103.3	96.4	103.2	96.4	NS	105.3 beets	7.52
	12	102.1	102.4	98.7	100.6	97.5	98.7	NS	107.6 beets	6.65
	13	103.0	99.7	98.6	102.0	99.8	96.9	NS	120.6 beets	7.95
	Ohio Avg	101.8	100.9	100.2	99.7	100.2	97.3	NS	100 %	2.43
	14	97.9	97.0	97.7	110.7	95.4	101.2	NS	126.1 beets	10.05
	16	100.7	102.0	98.0	102.5	99.9	96.8	NS	123.1 beets	6.65
	17*	96.4	99.8	101.8	104.1	99.6	98.2	NS	123.9 beets	6.82
	18	100.0	96.9	104.6	101.5	97.1	99.8	NS	112.6 beets	5.04
	Mich Avg	98.8	98.9	100.5	104.7	98.0	99.0	NS	100 %	3.03
	Grand Avg	100.0	99.8	100.4	102.5	98.9	98.3	NS	100 %	3.03

** & @, see page E6

1970, 6x6 LSQ tests, Data on % of Performance of General Mean (G.M.)

Item	Location Code**	Variety Code ^a						LSD 5 % on % G.M.	Actual G.M.	C.V.%
		1	2	3	4	5	6			
Leaf spot _{a/}	13	123.0	115.5	123.0	93.2	70.8	74.5	12.8	4.5 reading	10.66

_{a/} = 0 (no disease), 10 (completely defoliated)

** Location Code

- 11 - Russell Bros., Belmore, Ohio
- 12 - James Schroeder, Ottawa, Ohio
- 13 - Fausey Farm, Old Fort, Ohio
- 14 - Rudy Hetzner, Saginaw, Michigan
- 16 - Frahm Bros., Frankenmuth, Michigan
- 17 - Tom Schindler, Kawkawlin, Michigan
- 18 - Dale Smith, Alma, Michigan

^a Variety Code

Entry No.	Seed No.
1	UI(100363 x 2161) x SP6822-0
2	UI(100363 x 2161) x SP6528-0
3	UI(11863 x 12163) x SP6322-0
4	(EL31C2 x SP6121) x SP6322-0
5	SP67550-02 x SP6822-0
6	SP(6426-01 x 67555) x SP6822-0

1970 NURSERY EVALUATION TEST, FERDEN FARM, 7x8 RECTANGULAR LATTICE,
6 REPLICATIONS ANALYZED AS A RANDOM BLOCK EXPERIMENT.

Hybrid Parents			■	Performance in ■ of General Mean						
CMS	"O"	Pollen		1	2	3	4	5	6	7
SP6426-01		SP6822-0	2.3	97.2	100.9	95.9	96.5	99.7	101.5	99.4
SP67550-02		"	2.0	100.2	98.0	102.2	101.4	100.4	94.8	100.8
SP65599-01		"	1.7	96.0	93.4	102.5	102.0	100.2	98.5	100.5
SP6721-01	SP6423-0	"	2.7	107.0	110.3	96.9	97.7	99.6	104.5	99.2
UI1861	"	"	3.0	100.2	99.4	101.0	101.1	99.9	103.2	99.8
UI12163	"	"	3.0	102.1	104.6	97.9	99.0	99.4	109.1	98.9
UI100363	"	"	3.0	106.0	105.2	100.8	100.4	100.2	96.7	100.4
SP6721-01	SP673465-0	"	2.7	103.3	110.3	94.1	96.0	99.0	112.3	98.0
SP6423-01	"	"	2.7	95.7	99.4	96.1	97.9	99.0	113.9	98.2
SP6721-01	"	02 clone	2.7	82.2	83.4	98.7	100.1	99.3	112.6	98.7
SP6423-01	"	"	3.0	99.4	99.7	99.3	100.9	99.1	116.7	98.4
SP6621-01	SP663465-0	FC701/2	2.7	91.7	93.4	97.9	99.8	98.9	118.1	98.1
SP6423-01	"	"	3.0	94.5	96.3	97.8	99.3	99.2	114.0	98.5
UI12163	SP6721-0	SP6822-0	3.0	101.3	104.9	96.4	96.8	99.8	99.8	99.5
UI1861	SL133	"	2.7	114.6	110.9	103.1	101.8	100.7	90.6	101.2
UI100363	"	"	3.0	109.3	109.2	99.8	100.0	99.9	102.2	99.8
SP6423-01	UI4661	"	2.7	90.4	93.2	96.7	97.2	99.8	101.2	99.5
UI2161	"	"	2.7	102.1	108.9	94.1	95.5	99.3	106.9	98.5
SP6621-01	"	"	2.7	100.0	102.6	97.3	98.0	99.7	103.7	99.3
SL129X4661	"	"	2.7	93.9	96.9	96.8	96.6	100.2	92.6	100.2
SP65406-01	SP6442	SP6322-0	2.3	101.6	107.2	94.9	96.6	99.1	112.2	98.1
SL133	"	SP6528-01	3.0	103.0	99.4	103.5	102.1	100.8	89.0	101.4
UI100363	UI2161	"	3.0	110.7	110.3	100.4	100.0	100.2	96.5	100.4
SP66221-1	"	SP6322-0	2.7	111.0	114.9	96.3	97.5	99.4	108.0	98.8
SP66333-1	"	"	3.0	106.3	110.9	95.4	96.8	99.3	109.0	98.6
SP6121-01	UI3561	"	2.7	92.8	97.4	95.2	95.9	99.7	100.5	99.3
UI100363	UI2161	"	2.7	110.1	109.7	100.2	99.7	100.3	94.5	100.6
SL129	SL133	SP6528-01	3.3	110.4	106.3	103.4	102.5	100.4	94.7	100.9
"	"	SP6322-0	3.0	105.1	103.7	101.5	101.6	99.9	102.8	99.9
SP65550-1	"	"	2.0	99.9	97.2	102.7	101.1	100.8	86.8	101.5
SP67510-1	"	"	1.7	86.4	82.0	104.9	103.3	100.9	88.8	101.7
SP67516-1	"	"	2.7	91.9	88.6	103.4	103.2	100.0	103.4	100.1
SP67517-1	"	"	2.3	101.6	104.0	97.6	98.2	99.7	102.8	99.4
SP67523-1	"	"	2.0	94.3	90.6	104.1	102.3	101.0	85.6	101.8
SP67524-1	"	"	2.7	93.4	88.0	105.8	104.1	100.9	89.1	101.8
SP67527-1	"	"	1.7	92.2	87.4	105.3	104.1	100.5	95.8	101.1
SP67534-1	"	"	2.3	91.3	90.6	100.3	99.6	100.4	92.3	100.7
SP67535-1	"	"	2.0	98.2	92.6	105.9	104.6	100.6	94.3	101.3
SP67542-1	"	"	2.3	102.4	101.7	100.4	100.3	100.1	98.8	100.2
SP67543-1	"	"	2.0	91.6	89.2	102.5	101.9	100.3	96.3	100.7
SP67553-1	"	"	2.0	109.3	108.0	100.8	100.1	100.4	93.5	100.7
SP67557-1	"	"	2.7	101.5	99.2	102.1	101.0	100.6	90.7	101.1
SP67561-1	"	"	2.3	85.8	78.3	109.4	107.4	100.9	91.2	101.9
SP67588-2	"	"	3.0	95.2	94.9	100.0	99.6	100.2	95.8	100.4
SP6721-01	SP67555-0	SP6822-0	2.3	111.8	112.6	99.1	99.6	99.7	105.5	99.4
SP6423-01	"	"	2.0	101.2	100.9	100.4	100.9	99.8	105.1	99.6
SP6426-01	"	"	2.3	106.4	109.2	97.7	98.2	99.7	103.5	99.4
SP6643X027	"	"	2.7	93.1	96.6	96.0	97.3	99.4	107.7	98.8
SP64218-01	"	"	2.3	97.6	97.2	100.1	100.4	99.8	104.0	99.7
SP663465-01	"	"	2.3	98.4	98.3	99.9	100.0	99.9	101.4	99.8
SP67505-01	"	"	2.3	104.9	104.0	100.9	100.5	100.2	97.2	100.3
SP67519-01	"	"	2.0	102.9	99.7	103.2	102.4	100.4	96.2	100.8
SP67547-01	"	"	1.7	106.2	104.0	102.0	101.3	100.5	93.7	100.9
SP67550-01	"	SP66275-3	1.7	97.5	93.2	104.1	102.4	100.9	87.5	101.7
"	"	SP66288-24	2.0	102.6	100.0	102.4	100.8	100.9	85.9	101.6
SP65406-01	"	"	2.3	104.3	111.7	93.2	94.7	99.3	106.7	98.4
5% LSD (for above data units)			0.9	13.4	13.1	3.9	2.9	0.7	9.3	1.3
Actual General Mean			2.5	7966	30.2	264.3	15.92	94.72	27.2	82.9
Coefficient of Variability as %			21.01	11.77	11.53	3.44	2.58	0.58	8.22	1.1

■ = 8/12/70 Leaf spot ratings, East Lansing average of 3 replications

1 = Recoverable white sugar (pounds/acre)

2 = Roots in tons/A

3 = Recoverable white sugar (pounds/ton of roots)

4 = ■ Sucrose

5 = % (CJP) Clear Juice Purity

■ = Molasses sugar (pounds/ton of roots)

7 = Recoverable white sugar as percent of gross sugar

COOPERATOR: NORTHERN OHIO SUGAR COMPANY

BY: P. B. Brimhall, A. Erichsen, A. Suzuki,
R. Oldemeyer, D. Sunderland

LOCATION: Longanbach Farm, Fremont, Ohio

YEAR: 1970

(Results given are 10 plot averages in 1/2 of SP58222-0)

STRAIN	(a)		SUGAR CONTENT	(b)	
	RECOVERABLE SUGAR/ACRE	ROOT YIELD		THIN JUICE APP. PURITY	LEAFSPOT 10/1/70
(SP6721-01 X SP673465-0) X SP68222-0	90.0	97.2	96.8	99.6	2.7
(SP6423-01 X SP673465-0) X SP68222-0	98.9	103.6	98.1	99.5	2.7
(SP6423-01 X SP6528-01	106.8	112.3	97.8	99.3	3.2
SP6721-01 X SP6528-01	99.9	107.8	94.5	99.8	2.0
SL133 X SP6528-01	108.9	114.0	99.0	99.7	2.9
SP6721-01 X SP6322-0	85.9	89.1	97.9	100.8	2.5
SP64218-01 X SP6322-0	116.6	118.0	102.3	99.1	2.1
(SP65406 X SP6442) X SP6322-0	103.0	109.5	96.9	100.1	2.6
(EL31C2 X SP6121-0) X SP6528-01	109.4	109.5	102.0	99.4	2.5
(EL31C2 X SP6121-0) X SP6322-0	121.1	124.2+	100.7	98.9	2.8
(SL129 X 133) X SP6322-0	98.4	97.9	103.5	99.3	3.0
(SP64502 X SP6442) X SP6322-0	108.5	108.3	102.1	99.7	2.2
(SP6121-01 X EL31) X SP6322-0	101.6	107.6	94.5	99.2	2.6
(U1100363 X SP6121-0) X SP6322-0	115.6	118.4	100.1	99.6	2.4
EL35 X SP6528-01	122.8+	117.7	104.0	100.5	2.5
(SP6121-01 X EL35) X SP6322-0	112.0	109.1	100.0	100.9	2.2
FC506 X FC902	111.6	109.3	99.9	100.3	1.6
FC506 X SP6322-0	120.5	114.4	103.9	101.1	1.9
(SP6423-01 X SP67555-0) X FC701/2	104.7	102.8	103.3	99.8	2.6
(SP6426-01 X SP67555-0) X FC701/2	101.3	100.9	100.6	99.9	2.3
(SP67519-01 X SP67555-0) X FC701/2	94.6	95.9	101.6	99.5	2.1
SP6426-01 X SP6822-0	111.0	114.1	98.1	99.9	2.1
SP6599-01 X SP6822-0	105.6	108.3	98.8	99.6	1.7
SP67510-1 X SP6822-0	108.2	104.7	103.4	100.0	1.6

LOCATION: Longanbach Farm, Fremont, Ohio (Continued)

STRAIN	(a)		(b)	
	RECOVERABLE SUGAR/ACRE	ROOT YIELD	SUGAR CONTENT	THIN JUICE APP. PURITY
SP67516-1 X SP6822-0	105.3	105.6	101.9	99.0
SP67517-1 X SP6822-0	113.4	115.1	102.0	99.0
SP67523-1 X SP6822-0	113.4	111.0	103.9	99.6
SP67524-1 X SP6822-0	101.9	104.4	99.0	99.7
SP67527-1 X SP6822-0	104.6	103.1	102.1	99.9
SP67534-1 X SP6822-0	108.4	107.1	101.3	100.4
SP67535-1 X SP6822-0	108.3	105.9	102.3	100.4
SP67542-2 X SP6822-0	102.7	102.2	100.3	100.4
SP67543-1 X SP6822-0	114.3	113.2	105.1	98.8
SP67553-1 X SP6822-0	113.2	106.2	104.0	101.5+
SP67557-1 X SP6822-0	118.2	118.0	101.6	99.6
SP67561-1 X SP6822-0	113.9	110.1	107.3+	98.6
SP67588-1 or 2 X SP6822-0	115.5	110.7	103.2	100.4
(SP67547-01 X SP67555-0) X SP6822-0	110.4	109.6	100.5	100.4
SP653365-1 X SP6322-0	111.0	114.9	97.1	99.9
Mean for SP5822-0	6016. lbs.	23.67T	14.84%	92.49%
LSD 5% pt. (% of SP5822-0)	22.17	19.36	6.16	1.43
CV (%)	24.08	20.84	6.71	1.62

+ or - Statistically above or below SP5822-0 at 5% level of significance.

(a) Calculated by computer from formula used since 1954.

(b) 0 = no disease, 10 = completely defoliated.

VARIANCE TABLE - FREMONT LOCATION

SOURCE	(lbs)		(a)		(lbs)		(a)		(%)		(%)	
	RECOVERABLE											
	SUGAR				ROOTS				SUGAR		PURITY	
	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS
Replicates	9	1.41	9	126.66	9	1.49	9	23.33	9	23.33	9	23.33
Varieties	41	1.68	41	85.46	41	2.02**	41	6.37**	41	6.37**	41	6.37**
Random Block Error	314	1.70	322	80.31	322	1.01	322	1.01	314	2.24	314	2.24
Blocks (Elim. Var.)	60	1.29	60	64.21	60	1.57	60	2.23	60	2.23	60	2.23
Component (A)	48	1.30	48	63.14	48	1.55	48	2.23	48	2.23	48	2.23
Component (B)	12	1.26	12	68.51	12	1.61	12	2.23	12	2.23	12	2.23
Intra Block Error	254	1.79	262	84.00	262	1.01	262	2.25	254	2.25	254	2.25
TOTAL	364	1.69	372	82.00	372	1.22	372	3.23	364	3.23	364	3.23

(a Pounds per plot.

** Significant difference among varieties at 1% level.

AGRONOMIC EVALUATION TEST - 1970

USDA VARIETIES

CONDUCTED BY: P. B. Brimhall, Akio Suzuki, A. W. Erichsen,
R. K. Oldemeyer and D. L. Sunderland

LOCATION: Fremont

COOPERATOR: Northern Ohio Sugar Company, Fremont, Ohio

DATE OF PLANTING: April 11, 1970

DATE OF HARVEST: October 8, 1970

EXPERIMENTAL DESIGN: Simple rectangular lattice

SIZE OF PLOTS: 1 row X 20 ft. X 10 replications, 30 inch row spacing

HARVEST AREA/PLOT: 1 row X 15 ft.

SAMPLES FOR SUCROSE
AND PURITY DETERMINATIONS: One sample per plot

RECENT FIELD HISTORY: Tomatoes 1969, fall plowed

FERTILIZATION OF PRET CROP: Plowdown 120-100-125, starter 160 lbs. 6/24/12

LEAFSPOT EXPOSURE: Mild to moderate, readings taken October 1, 1970

BLACKROOT EXPOSURE: Mild, no loss of stand

OTHER DISEASES: Crown rot (Rhizoctonia) caused considerable loss of
stand during growing season

SOIL AND SEASONAL
CONDITIONS: Soil type was silty clay loam, excellent growing
conditions

REALIABILITY OF TEST: Fair

COOPERATOR: NORTHERN OHIO SUGAR COMPANY

BY: P. B. Brimhall, A. Erichsen, A. Suzuki,
R. Oldemeyer, D. Sunderland

LOCATION: Fausey Farm, Old Fort, Ohio

YEAR: 1970

(Results given are ■ plot averages in ■ of SP5822-0)

STRAIN	(a)			(b)	
	RECOVERABLE SUGAR/ACRE	ROOT YIELD	SUGAR CONTENT	THIN JUICE APP. PURITY	LEAFSPOT 10/1/70
(SP6721-01 X SP673465-0) X SP6822-0	102.6	104.1	97.7	100.8	3.9
(SP6423-01 X SP673465-0) X SP6822-0	103.2	107.2	99.2	98.4-	4.4
SP6423-01 X SP6528-01	84.7	87.6	96.9	100.4	5.1
SP6721-01 X SP6528-01	96.2	100.8	96.8	99.6	4.3
SL133 X SP6528-01	100.7	99.0	101.4	100.2	4.3
SP6721-01 X SP6322-0	106.7	108.4	98.9	99.8	4.0
SP64218-01 X SP6322-0	105.3	103.0	104.0	98.8	4.1
(SP65406 X SP6442) X SP6322-0	107.7	111.9	97.3	99.7	4.9
EL31C2 X SP6121-0) X SP6528-01	106.2	104.9	99.5	100.5	4.7
(EL31C2 X SP6121-0) X SP6322-0	105.6	104.7	98.2	101.1	4.4
(SL129 X 133) X SP6322-0	109.2	112.2	96.7	100.3	4.7
(SP64502 X SP6442) X SP6322-0	103.3	104.0	100.7	99.1	3.7
(SP6121-01 X EL31) X SP6322-0	108.2	110.7	98.3	100.0	4.6
UI100363 X SP6121-0) X SP6322-0	97.2	97.9	99.1	100.1	4.4
EL35 X SP6528-01	120.7+	119.4+	99.4	101.3	5.0
(SP6121-01 X EL35) X SP6322-0	123.4+	123.0+	99.3	100.8	4.3
FC506 X FC902	112.6	111.2	100.5	100.7	3.8
FC506 X SP6322-0	120.3+	119.0+	103.8	98.5-	2.3
(SP6423-01 X SP67555-0) X FC70/2	100.1	97.2	104.5+	99.3	5.3
(SP6426-01 X SP67555-0) X FC70/2	103.6	101.9	102.3	99.5	4.0
(SP67519-01 X SP67555-0) X FC70/2	102.9	99.8	104.6+	99.7	3.8
SP6426-01 X SP6822-0	97.9	101.0	96.2	100.2	4.1
SP65599-01 X SP6822-0	112.7	105.6	106.3+	100.2	3.0
SP67510-1 X SP6822-0	109.6	101.9	105.3+	101.1	2.3

LOCATION: Fausey Farm, Old Fort, Ohio (Continued)

STRAIN	(a)		ROOT YIELD	SUGAR CONTENT	THIN JUICE APP. PURITY	(b) LEAFSPOT 10/1/70
	RECOVERABLE SUGAR/ACRE					
SP67516-1 X SP6822-0	109.9		106.3	104.6+	98.9	4.2
SP67517-1 X SP6822-0	102.2		103.5	97.7	100.7	4.9
SP67523-1 X SP6822-0	114.0		108.6	104.3+	100.2	2.9
SP67524-1 X SP6822-0	91.8		88.3	103.3	100.4	3.7
SP67527-1 X SP6822-0	113.0		103.7	105.9+	101.3	2.9
SP67534-1 X SP6822-0	114.7		114.2	100.5	100.2	3.6
SP67535-1 X SP6822-0	107.0		100.0	106.2+	100.2	3.1
SP67542-2 X SP6822-0	105.0		102.7	100.4	100.8	4.5
SP67543-1 X SP6822-0	113.7		107.2	106.3+	99.6	2.9
SP67553-1 X SP6822-0	124.3+		118.4+	103.2	101.1	3.1
SP67557-1 X SP6822-0	125.4+		119.2+	104.0	100.2	3.1
SP67561-1 X SP6822-0	105.2		98.6	107.4+	99.6	2.9
SP67588-1 or 2 X SP6822-0	116.4		108.3	104.9+	101.4	3.8
(SP67547-01 X SP67555-0) X SP6822-0	114.5		107.3	104.2	100.8	2.8
SP653365-1 X SP6322-0	108.9		109.1	99.4	100.3	3.8
Mean for SP5822-0	4604. lbs.		19.29T	14.26%	92.00%	3.9
LSD 5% pt. (% of SP5822-0)	17.34		16.14	4.25	1.37	---
CV (%)	16.14		15.39	4.10	1.29	---

† or - Statistically above or below the check at the 5% level of significance.

(a) Calculated by computer from formula used since 1954.

(b) Q = no disease, 10 = completely defoliated.

VARIANCE TABLE - OLD FORT LOCATION

SOURCE	(lbs)			(a)			(%)			(%)		
	RECOVERABLE			ROOTS			SUGAR			PURITY		
	DF	SUGAR	MS	DF	MS		DF	MS		DF	MS	
Replicates	7	4.15		7	212.65		7	3.52		7	17.29	
Varieties	41	.95**		41	53.15**		41	1.77**		41	5.51**	
Random Block error	272	.49		277	29.65		276	.39		273	1.81	
Blocks (Elim. Var.)	48	.57		48	32.24		48	.55		48	3.63	
Component (A)	36	.62		36	35.33		36	.53		36	3.47	
Component (B)	12	.40		12	22.98		12	.61		12	4.09	
Intra Block Error	224	.47		229	29.10		228	.35		225	1.42	
TOTAL	320	.63		325	36.55		324	.63		321	2.62	

(a) Pounds per plot

** Significant difference among varieties at 1% level.

AGRONOMIC EVALUATION TEST - 1970

USDA VARIETIES

CONDUCTED BY: P. B. Brimhall, Akio Suzuki, A. W. Erichsen,
R. K. Oldemeyer and D. L. Sunderland

LOCATION: Old Fort, Ohio

COOPERATOR: Northern Ohio Sugar Company, Fremont, Ohio

DATE OF PLANTING: April 23, 1970

DATE OF HARVEST: September 28, 1970

EXPERIMENTAL DESIGN: Simple Rectangular Lattice

SIZE OF PLOTS: 1 row X 20 ft. X 10 replications, 30 inch row spacing

HARVEST AREA/PLOT: 1 row X 15 ft. (Only eight replicates analyzed)

SAMPLES FOR SUCROSE AND PURITY DETERMINATIONS: One sample per plot

RECENT FIELD HISTORY: Sugar beets 1969, Spring plowed

FERTILIZATION OF ~~WET~~ CROP: Plowdown 80-220-240, starter 150 lbs. 6/24/12

LEAFSPOT EXPOSURE: Very severe, readings taken August 28, 1970

BLACKROOT EXPOSURE: Mild, no loss of stand

OTHER DISEASES: Some root rot symptoms present, probably due to extremely wet conditions first half of growing season

SOIL AND SEASONAL CONDITIONS: Soil was a sandy loam, ppt. was excessive during May, June, and July

REALIABILITY OF TEST: Fair

VARIETAL RESISTANCE TO RHIZOCTONIA

By G. J. Hogaboam and C. L. Schneider

This experiment was planned with single row plots 23 ft long with three replications per entry. The experiment was planted on land which was new to the Botany Department. At emergence time we discovered we had an Atrozone problem. This was especially bad across series 1 and 2 which eliminated the first replication of two experiments. After the plants were blocked and thinned Rhizoctonia inoculations were made by Dr. Schneider according to methods described in his report, "Sugarbeet Disease Investigations at East Lansing, Michigan in 1970". Since over 300 plots were involved a more rapid way of scoring the varieties for Rhizoctonia resistance was necessary. A rating was devised on a scale of 0 through 9. Where 0 indicated no disease and 9 would indicate about 90 to 100% of the plants missing. A rating was made on the 14th of August and then again on September 16. At harvest time the plants were scored in a somewhat different manner. We counted the number of unblemished roots in a 20 ft row and divided that by 2, hence a score of 10 would be a top score and a 0 would indicate that all of the roots had been affected in some manner with Rhizoctonia. With a harvest rating of this type, it was then necessary to subtract the harvest score from 9 in order to have approximately the same basis as the other two readings.

Results

In general, the 0-type material and their cms equivalents were by far the most susceptible things in the field. This was followed by slightly more resistant lines which were in our monogerm and multigerm improvement program without any previous Rhizoctonia selection. Amongst the 0-type and their cms equivalent material, we did have some lines that were significantly better than others. It should be noted, however, that the most resistant of the 0-types was on more of a survival level than of an immunity level.

In 1968, selections were made for Rhizoctonia resistance from East Lansing breeding material as well as from Fort Collins' Rhizoctonia resistant material. The East Lansing material produced seed at one polycross location while the Fort Collins material produced seed at other seed locations. Both polycrosses were evaluated by individual plant progeny in the 1970 Rhizoctonia nursery. One selection for Rhizoctonia resistance in the East Lansing material was not significantly better than the susceptible check C817 which is used by Gaskill, at any of the three readings. There was a significant difference between the selections from Fort Collins and those from East Lansing at the September 16 and at the harvest dates.

Six hybrids were compared for Rhizoctonia resistance, in which there were two F_1 female lines involved and three pollinators. The female F_1 lines were SP6423-01 x SP673465-0 and SP6721-01 x SP673465-0. The male lines were FC701/2, 02 clone and SP6822-0. The hybrids with 02 clone as

a pollinator were significantly more susceptible than those with the FC701/2 as a pollinator in the August 14 readings and the September 16 readings and at harvest. In the September 16 readings, those pollinated by SP6822-0 were more susceptible than those pollinated by FC701/2. The FC701/2 hybrids were numerically less resistant than the average of the Fort Collins resistant material, but this difference was not significant.

Selections were made from the breeding material to continue the Rhizoctonia resistance breeding program.

Tables 1 and 2 summarize the results of the Rhizoctonia nursery tests for disease resistance.

Table 1. Average, Range, Replications, LSD 5%, and Coefficient of Variability (CV) by reading date and experiment for material in the Rhizoctonia Nursery.

Type of Material	Expt.	Date	\bar{x}	Range	Repl.	LSD 5%	CV
1969 0 types and CMS equivalents (24 entries)	0a	8-14	7.90	5-9	2	1.54	9.45
	0a	9-16	8.10	7-9	2	1.14	6.80
	0a	Harvest	8.23	6-9	2	1.24	7.30
1970 0 type Polycross (17 entries)	0b	8-14	6.25	1-9	3	NS	28.57
	0b	9-16	7.63	5-9	3	1.28	10.12
	0b	Harvest	8.25	6-9	3	NS	8.55
E. Lansing breeding material with one or less selection for Rhizoctonia resistance	3	8-14	5.80	1-9	2	NS	34.52
	3	9-16	7.02	4-9	2	NS	12.06
	3	Harvest	7.42	3-9	2	NS	13.63
Except for susceptible check, all material has had some selection for Rhizoctonia resistance.	5	8-14	1.67	0-7	3	2.19	80.05
	5	9-16	3.85	0-8	3	2.09	33.35
	5	Harvest	5.58	0-9	3	2.20	24.11

Table 2. Average and range by population group for the three reading dates for Experiment 5.

Population Group		8-14		9-16		Harvest	
		\bar{x}	range	\bar{x}	range	\bar{x}	range
SP621220H0, Gaskill's susceptible ck.	entry 523	2.00	1-4	4.33	2-7	7.00	6-8
FC701/2 male 2 female lines	entries 529 5 530	1.33	1-2	2.33	1-5	4.33	3-5
SP6822-0 " " " " (same)	" 534 5 536	2.00	1-3	5.17	2-6	6.00	3-7
02 clone " " " " (same)	" 533 5 535	4.00	2-7	6.66	6-8	7.83	7-8
FC701/2 male 5 female lines	entries 528 thru 532	0.93	0-2	2.33	0-5	4.47	0-8
FC701/2 5 FC701/4	entries 521 5 522	0.50	0-2	1.17	0-2	3.33	2-5
FC702/2 5 FC702/4	" 524 5 525	1.33	0-2	2.00	1-4	4.50	3-5
E.L. Rhiz. Sel. from FC701	entries 518, 519, 520	0.56	0-2	1.22	0-2	2.67	1-4
" " " " SP671222-0(mm)	entries 514 5 515	0.33	0-1	1.17	1-2	3.50	2-5
" " " " E.L. multigerm lines	" 501 thru 513	2.50	0-7	5.94	3-8	7.39	5-9
FC material from SP5831-0(mm)	" 526 thru 527	0.33	0-2	1.83	0-4	4.00	2-6

BREEDING SUGARBEETS FOR RESISTANCE TO BLACK ROOT AND LEAF SPOT

G. E. Coe

Research work on sugarbeets at the Plant Industry Station, Beltsville, Md. is directed mainly toward varietal improvement in resistance to *Aphanomyces* black root and *Cercospora* leaf spot which are important diseases in eastern United States.

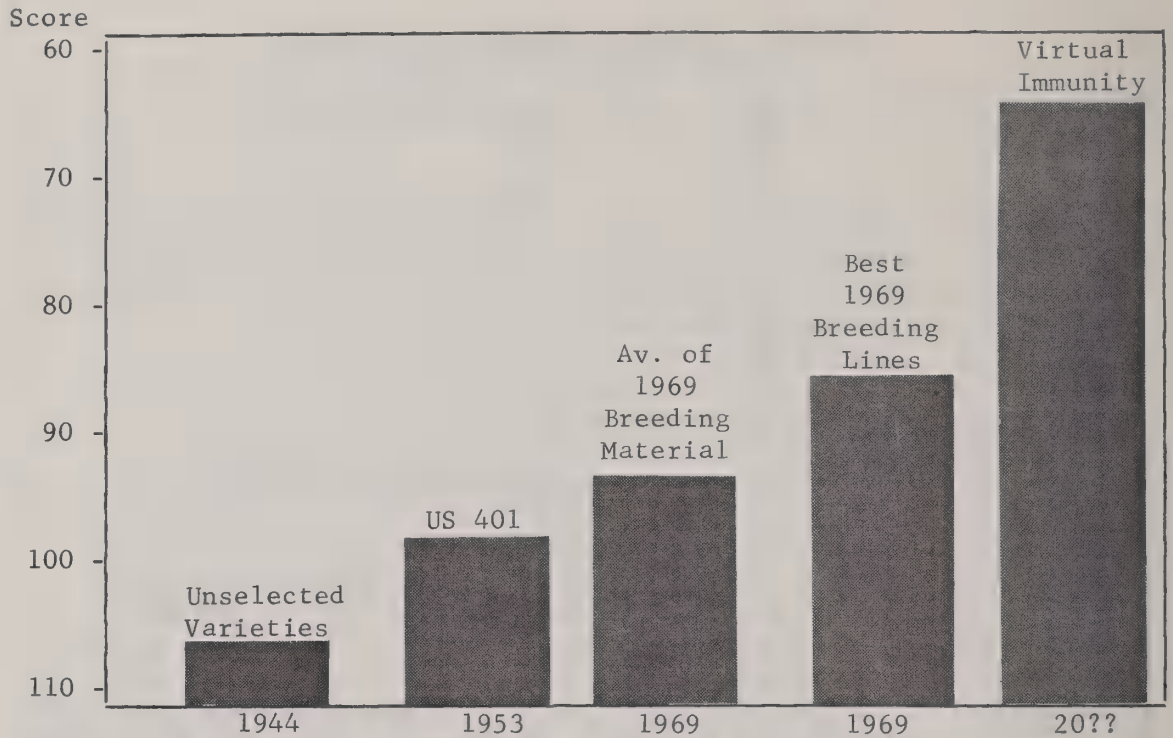
This report attempts to evaluate our present status in resistance to these two diseases, and in breeding for globe-shaped roots.

Progress in Improving Black Root Resistance

It is quite difficult to measure improvement in *Aphanomyces* black root resistance of sugarbeet lines especially if one attempts to compare successive generations with each other. However, if one compares varieties several years removed from each other differences can be seen. Any attempt to compare varieties in disease resistance is at best only an approximation because the severity of the disease affects the apparent relative resistance of varieties, and because the scale for evaluating resistance influences the apparent magnitude of the differences observed. Based on the manner in which sugarbeets are presently being tested at Beltsville, Graph 1 shows the progress that has been made. The short bar on the left is representative of varieties which have never been selected for black root resistance, and consequently all plants die in our greenhouse test. In 1944, there were no varieties with resistance to black root. By 1953, US 401 had a degree of resistance represented by the 2nd bar from the left. The average of the 1969 breeding material had the amount of resistance represented by the 3rd bar. Even the most black root tolerant 1969 lines had only about half as much resistance as would be required for them to be virtually immune. Although reasonable progress has been made in increasing black root resistance, additional resistance seems to be gained in smaller increments each year. Perhaps immunity can never be realized within the existing resistant selections. On the other hand, if commercial varieties had as much resistance as the most resistant breeding lines, field losses caused by black root as it presently exists would be undetectable.

Progress in Improving Leaf Spot Resistance

The amount sugarbeets have improved in leaf spot resistance can also only be measured on the same sort of basis as was just done for black root resistance. Graph 2 depicts the progress made in improving the resistance of sugarbeets to *Cercospora* leaf spot. Selections for resistance to this disease were started in about 1922. The bar on the left represents the amount of resistance exhibited by most varieties which have never been selected for leaf spot resistance. By 1953, a fair amount of resistance had been achieved and is represented by the 2nd bar from



Graph 1. Black root resistance of sugarbeet lines.



Graph 2. Leaf spot resistance of sugarbeet lines.

the left in Graph 2. This amount of resistance is not considered good, however, when compared to the best 1969 breeding lines which are represented by the 4th bar from the left. These breeding lines need only 25 to 35 percent more resistance to be immune under present testing conditions. These best breeding lines exhibit almost no symptoms of the disease in sugarbeet growing areas even in years when the disease is considered severe. Their loss in sugar production from leaf spot disease is minimal. As the level of leaf spot resistance gets better, it has become increasingly difficult to achieve added increments of resistance. However, more improvement is still considered possible.

Reasonably good resistance has been found in some monogerm 0-types. Unfortunately, none of those with the most resistance have had enough combining ability to give satisfactory yields. Results of leaf spot nursery tests of some of our more recent monogerm 0-types are presented in Table 1.

Table 1. Leaf spot ratings of monogerm 0-types and their male-sterile companion lines in the 1970 Beltsville leaf spot nursery.

Variety Number	Average Leaf Spot Rating*	Variety Number	Average Leaf Spot Rating*
SP 6922-0 (Resistant check Variety)	3.3		
SP 69513-0 mm PF	3.0	SP 69550-0 mm PF	3.0
SP 69513-01 mm MS	3.3	SP 69550-01 mm MS	3.0
SP 69514-0 mm PF	3.0	SP 69557-0 mm PF	2.0
SP 69514-01 mm MS	3.0	SP 69557-01 mm MS	2.0
SP 69517-0 mm PF	3.0	SP 69561-0 mm PF	2.5
SP 69517-01 mm MS	3.0	SP 69561-01 mm MS	2.5
SP 69523-0 mm PF	3.0	SP 69569-0 mm PF	2.3
SP 69523-01 mm MS	3.7	SP (67550-02X67569) mm MS	2.0
SP 69524-0 mm PF	5.5	SP 69586-0 mm PF	5.3
SP 69524-01 mm MS	5.3	SP 69586-01 mm MS	5.0
SP 69542-0 mm PF	4.0	SP 69588-0 mm PF	2.0
SP 69542-01 mm MS	4.0	SP 69588-01 mm MS	2.5

0 = No leaf spot; 10 = All leaves dead

It appears that all except 4 of the varieties listed are as good as SP 6922-0, the resistant check variety, and all except these 4 should be usable if they have satisfactory combining ability. SP 69517-01, SP 69550-01, and SP 69557-01, appear to have enough combining ability to be worthy of testing in 3-way experimental hybrid production.

Breeding for Globe-Shaped Beets

Forty-one F_2 populations from crosses of globe-shaped beets X leaf spot and black root resistant sugarbeets were grown in the Beltsville leaf spot nursery in 1970. The seed was sown in rows 2 ft. apart and plants were thinned to a 2 inch spacing within the row. The stand at harvest time, however, varied greatly because of losses to root rotting diseases. Final stands ranged from 29,000 to 90,000 plants per acre. All were comparatively poor in leaf spot resistance, being no more resistant than US 401. Root yield varied from 8 to 24 tons per acre. Sugar analyses were not run on this material. Only 18 of the 41 F_2 populations segregated roots with shapes other than the normal sugarbeet root shape. The segregating populations had as few as 2 globe-shaped roots per 400 to as many as 92 per 400 roots. However, this should not be considered meaningful in these field run populations. The shape of the roots varied considerably between populations. One F_2 progeny, SP 70603-05, produced globe-shaped segregates with the most desirable characteristics (Fig. 1). They had small crowns, approached a spherical shape, and had almost no feeder roots or root hairs on the large part of the beet. These smooth-surfaced roots came out of the ground almost completely free of soil. The best of the selected roots are being used for another cross to leaf spot and black root resistant sugarbeets. The remainder are being used to produce experimental hybrids.



Fig. 1. Globular sugarbeets. Note small crowns and smoothness of roots.

SEED PRODUCTION PROGRAM FOR THE EASTERN AREA

R. C. Zielke

In cooperation with the F & M Beet Sugar Association, Saginaw, Michigan, much work has been done on breeding line improvement, increasing elite and stock seed quantities, and producing experimental hybrids for testing in the eastern United States. Table 1 lists the numbers and types of seedlots produced by location and year and the number of lines grown in the Oregon "observation" tests.

Table 1. Number of Seedlot Productions and Variety Observations in Oregon.

<u>Year</u>	<u>Exp. Hybrids (single & 3-way crosses)</u>	<u>F₁ CMS crosses</u>	<u>Elite Increases</u>	<u>Seed Prod. Location</u>	<u>Oregon Observations</u>
1966	18	18	6	Owosso, Mi	-
1967	54	11	5	Owosso, Mi	50
1968	- 84	4 28	- -	E. Lansing Oregon	58
1969	- 61	- -	2 -	E. Lansing Oregon	53
1970	11 7	7 -	5 -	E. Lansing Oregon	39
1971*	3 14	4 21	3 -	E. Lansing Oregon	40
TOTALS	252	93	20		240

* Productions growing or planned for seed production in 1971.

Seedlot Distribution

Seed from the above productions was extensively tested in nursery and screening tests at Beltsville, Md. (by G. Coe) and E. Lansing, Mich. (by Hogaboam and Zielke). Area screening and commercial evaluations were conducted in Michigan and Ohio by the F & M Beet Sugar Association (by J. Niederer and J. Brown). Results from most of these tests are reported each year in this periodical, Sugarbeet Research.

Extra quantities of seed have been available such that distributions were also made to cooperative investigators in other areas. The number of experimental hybrid crosses distributed by year and cooperator are listed in Table 2.

Table 2. Number of Experimental Seedlots Distributed to Cooperative Testing Agencies.

<u>Year</u>	<u>No. Distributed</u>	<u>To</u>
1968	40	American Crystal Sugar Co.
"	40	Holly Sugar Corp.
"	31	G. W. Sugar Co. (for Northern Ohio area)
"	40	Cornell University (Dr. R. Anderson)
1969	120	American Crystal Sugar Co.
"	40(est.)	Holly Sugar Corp.
"	35	G. W. Sugar Co. (for Northern Ohio area)
"	40(est.)	Cornell University (Dr. R. Anderson)
1970	130	American Crystal Sugar Co.
"	88	Holly Sugar Corp.
"	21	G. W. Sugar Co. (for Northern Ohio area)
"	5	Fort Collins (J. Gaskill)

Affect of Locations on Bigerm and Twin Ovule Development

Germination counts and observations on the 1967 Michigan and 1969 Ohio seed productions pointedly illustrate the affect of locations on bigerm and twin ovule development in seed harvested from the female lines. Seedlots were processed and sized very carefully; determinations for percent bigerms were calculated on the basis of 100 seedballs per germination sample (unreplicated) and percent twin ovules was determined only on those seedballs which germinated (usually over 80%). Results for the bigerm and twin ovule counts are given in Tables 3 and 4.

Table 3. Percent Bigerms and Twin Ovules in Selected Hybrid Seedlots Produced at Owosso, Michigan, in 1967.

Females	Loc.*	Bigerms (%)			Twin Ovules (%)		
		Seed Dia. (64ths)			Seed Dia. (64ths)		
		10½	9½	8½	10½	9½	8½
SP6621-01	1	2	0	0	7	4	1
"	2	26	15	6	1	0	0
"	3	7	0	2	9	5	1
"	4	8	2	1	17	6	5
SP581181s1	1	0	0	0	0	1	0
"	2	2	1	0	0	0	0
"	3	1	1	0	0	0	0
"	4	0	0	0	2	0	0
SP65406-01 x SP643465-0	1	0	0	0	0	1	0
"	2	0	0	0	0	0	0
SP65406-01 x SP6442-0	1	0	0	0	21	14	1
"	2	1	0	0	1	0	0

* Pollinators at these locations were: 1-02 clone, 2-SP6322-0, 3-SP6528-01, and 4-SP6629-0

Even though the locations above were within an 8-mile radius and planted within a 3-day span (Apr. 26-28), striking differences are apparent between locations for both bigerm and twin ovule development in two of the four monogerm female lines (SP6621-01) and (SP65406-01 x SP6442-0). The other two female lines have very low percentages of bigerms and twin ovules at all their respective locations. For another example of location influence, notice that the only difference between the two F₁ females listed is the 0 type pollinator. Yet, bigerms only developed at location number 1 when SP6442-0 was the pollinator and not at all where SP643465-0 was the pollinator.

Table 4. Percent Bigerms and Twin Ovules in Selected Hybrid Seedlots Produced at Salem, Oregon in 1969.

Females	Loc.*	Bigerms (%)		Twin Ovules (%)	
		Seed Dia. (64ths)		Seed Dia. (64ths)	
		over 9½	8½-9½	over 9½	8½-9½
UI12163 X SP673465-0	1	1	0	0	0
" "	2	3	0	0	0
SP6423-01 X UI4661	1	13	2	4	9
" "	2	0	0	23	2
SP6721-01 X SP673465-0	1	28	14	2	1
" "	2	31	9	4	2
SP673465-01 X SP6721-0	1	26	5	0	0
" "	2	25	7	3	6

* Pollinators at these locations were: 1-02 clone, 2-SP6822-0

Bigerm and twin ovule development for the first female listed in Table 4 was uniform at two locations. The second female listed, however, had opposite reactions for both characters, i.e., bigerms at location 1 and twin ovules at location 2. The female SP6721-01 x SP673465-0 and its reciprocal show essentially little difference between the reciprocals or between locations.

Fortunately, most of the bigerm and multigerm fractions in commercial seedlots can be removed by screening methods. Planting seed to stand, however, is rapidly becoming a grower practice in Michigan and Ohio, and seedlots containing a low percentage of twin ovules would be highly desirable. The data presented in Tables 3 and 4 show that certain breeding lines are capable of producing a low percentage of twin ovules and/or bigerms over many locations and, also, that some lines may be highly variable in expression of these characters.

POWERED AUGER USED TO DIG HOLES FOR MOTHER ROOTS

R. C. Zielke

Transplanting mother roots for seed production can be laborious and slow if the holes have to be dug manually with a spade or shovel (e.g., garden locations). A small, powered, relatively inexpensive post hole auger can alleviate much of the hard work in excavating holes.

The auger we use has a 3HP, 2 cycle, gasoline engine, wind-up starter, automatic centrifugal clutch, weighs about 55 pounds, and stands approximately 4 feet tall. The 9-inch auger bit excavates holes big enough for the largest roots and provides loose soil to repack around the transplanted root.

One man can handily operate the machine in loose, tilled soil but two men may be necessary when the soil is firm. In either case, it is possible to dig a hole 10 inches in diameter and 12 inches deep every 15 seconds (60 holes in 15 minutes) if stones imbedded in the soil are not too numerous or large. Soil conditions can be assessed in a few hours by renting and testing a machine.

SUGARBEET DISEASE INVESTIGATIONS AT
EAST LANSING, MICHIGAN IN 1970

C. L. Schneider

I. Testing Disease Resistance.

(G. J. Hogaboam and R. C. Zielke, cooperators)

A. Aphanomyces screening tests. Breeding lines from the East Lansing station were tested in the greenhouse for resistance to the beet water mold, Aphanomyces cochlioides. Infection was initiated with dry oospore inoculum, prepared in accordance with a previous report (Sugarbeet Research 1969 Report: E27-29). Inoculum was added with the seed at rates of 5-10 c.c. per 4-in. pot of steamed soil. Time and labor involved in oospore inoculum preparation and application were about one-half of that previously required with zoospore inoculum. Relatively high temperature and soil moisture were maintained. In each test of 12 entries replicated five times, commercial variety US H20 was included as a standard for comparison. Disease severity evaluations were made about six weeks after planting. The grouping of the 162 entries according to degree of disease susceptibility was as follows:

<u>Disease rating classes</u> <u>in pct. of US H20</u>	<u>Number of entries</u> <u>in each class</u>
50-69	3
70-89	39
90-109	69
110-129	35
130-149	10
150-169	6

B. Selection for Aphanomyces resistance in the greenhouse. In 1967, seedlings of five multigerm O-type lines were immersed in petri plates containing $0.5-1.1 \times 10^6$ A. cochlioides zoospores for about 6 hours in accordance with an inoculation method previously described (H. S. MacWithey, 1961, Jour. A.S.S.B.T. 11: 309-312). The seedlings were then planted, 4-5 per pot, in steamed soil. Among the plants that survived the severe disease infection that ensued, 43 out of a total of 515 inoculated were selected because they appeared to be more disease-resistant. After the selected plants had produced mature roots, they were grouped in a seed production plot. In 1970, the lines derived from the selections together with the five lines from which the selections were made were tested in the greenhouse for resistance to A. cochlioides. The inoculation tests, in which oospore inoculum was used, showed differences in degree of disease resistance among the lines. Among 43 lines derived from the 1967 selections, 10 had disease severity ratings that were significantly lower than those of their parent lines. The other 33 lines had ratings essentially the same as the parent lines.

C. Rhizoctonia Nursery. Breeding lines, including several derived from plants selected for resistance to Rhizoctonia were grown in the Rhizoctonia nursery located in Michigan State University Department of Botany and Plant

Pathology field plot area. Each entry was represented by three plots, each 20 ft. long. Thirty days after planting, dried sorghum grain inoculum of R. solani was side-dressed on each side of the seedling rows at the total of 4 c.c. per foot of row. On 9 and 22 July the grain inoculum, ground to a meal-like consistency, was thrown into the plant crowns at the rate of 2 c.c. per ft. of row. By 14 August there were significant differences in severity of crown rot among entries. By harvest time, differences between some entries in apparent resistance to Rhizoctonia damage were very striking (Fig. 1). All plants were dug and examined at harvest. Root rot ratings, based on a 0-10 index ranged from 2.7 to 7.3. The superior ratings were confined to cultivars developed in the Rhizoctonia resistance breeding program at Fort Collins. Roots were selected from among the most resistant-appearing survivors as sources of resistance in the breeding program for Rhizoctonia resistance developed at the East Lansing Station.

D. Testing Rhizoctonia resistance in the greenhouse. Studies were continued on greenhouse testing of Rhizoctonia resistance with the objective of decreasing time, labor and space needed in the program of developing Rhizoctonia-resistant sugarbeets. Plants of two cultivars that differ in degree of Rhizoctonia susceptibility in field tests were exposed to 5 c.c. of dried sorghum inoculum in the crowns when they were about 6 weeks old. Five plants of each cultivar were separately exposed to 18 R. solani isolates from Michigan and Ohio. Differences in root rot susceptibility between the two cultivars were apparent within 6 weeks after inoculation as the following results show:

<u>Cultivar</u>	<u>Root rot severity rating (index: 0-4)</u>
SP671008-0	1.9 (Range = 1.0-2.6)
SP621220HO	3.0 (Range = 1.8-4.0)

J. O. Gaskill, from whom the seed of the cultivars was obtained, previously reported similar significant differences between these cultivars (Sugarbeet Research 1969 Report: D10-13). In additional greenhouse inoculation tests, six cultivars from J. O. Gaskill that had been developed for Rhizoctonia resistance, and a non-resistant type, were separately inoculated with six of the most virulent R. solani isolates among the 18 isolates previously employed. Differences in susceptibility to Rhizoctonia between cultivars in the greenhouse test were indicative of the differences between them observed in the Rhizoctonia nursery in 1970 (Table 1).

E. Cercospora Nursery. Field plots of breeding lines were tested for resistance to the leaf spot fungus Cercospora beticola. In the nursery were 212 entries in 20 ft. plots replicated three times. Finely-ground Cercospora-infected sugarbeet leaf inoculum was applied on 15 June with a mist blower crop duster. Approximately 17 liters of dry inoculum were distributed over 1.11 acres of plot area. By 12 August a moderately severe epiphytotic had developed with significant differences in leaf spot severity between entries. Disease severity ratings ranged from 1.3 to 3.3, based on a 0-10 index. The mean severity rating of commercial variety US H20 was 2.7. Disease intensity increased after the 12 August ratings but differences between entries were less easily discernible.

II. Chemical Control.

A. Field tests of fungicides (H. S. Potter, Cooperator).¹ Plots of variety US H20 were planted in late May in soil naturally infested with Aphanomyces cochlioides. Five seed treatments were applied as slurries and four soil treatments were applied as aqueous sprays at 100 gal/acre or as granules in a 10-in. band along the drill row just before planting. Banded materials were worked into the soil with a rotary hoe to a depth of about one inch. Severe damage by A. cochlioides occurred in June and July when the soil was extremely wet. By 27 July, the only treatments with stands better than the untreated control were those that contained DASS (p-dimethylaminobenzenediazo sodium sulfonate).

Six fungicides at several concentrations were applied as soil treatments and as crown sprays to control Rhizoctonia root rot. Plots were sidedressed with dried grain inoculum at the total rate of 4 c.c. per row. Soil treatments were applied as aqueous sprays in the drill row immediately before planting. Crown sprays were applied six times at 2-week intervals with hand sprayers at 100 gal/acre beginning 23 June. Shortly after plots were infested, stands progressively declined throughout the remainder of the season as a result of Rhizoctonia attack. PCNB (pentachloronitrobenzene) at 2 lb active/acre gave outstanding control as a crown spray with an average stand of 18.4 plants per 20 ft. row compared with a stand of 3.7 plants for the untreated control (Fig. 2). Other crown sprays that gave stands better than control included benomyl (.32 lb/acre) and 1, 2, -bis(3-methoxycarbonyl-2-thioreido) benzene (.53 lb/acre). PCNB soil treatment at 4 lb active/acre also gave stands better than untreated control but it was not as effective as the crown spray.

Sixteen chemical treatments for controlling Cercospora beticola leaf spot disease were tested. Plots of variety US H20 were artificially infested with the fungus on 15 June. Beginning on 8 July, fungicidal sprays were applied with hand sprayers at 100 gal/acre in six (14-day intervals) or four (21-day intervals). All chemical treatments reduced disease severity compared with untreated check. Outstanding treatments included benomyl (.13 and .25 lb active/acre), thiabendazole (.19 and .38 lb active/acre), and -1, 2, -bis (3-methoxycarbonyl-2-thioreido) benzene. Benomyl applied at the rate of .38 lb active/acre every 21 days was as effective as when it was applied at .25 lb/acre every 14 days.

Efficacy of five approved fungicides in controlling Cercospora leaf spot was evaluated in a field test in cooperation with Fred B. Russell, Buckeye Sugars, Inc. and the grower, James Schroeder, at Ottawa, Ohio. Sprays were applied with a boom mounted on a Piper Pawnee aircraft by J. L. Frey of Pandora, Ohio. A total of five applications at 5 gal/acre were applied on a 14-day schedule. Each treatment was represented by two plots 2,640 ft. long and 116 ft. wide. A natural epiphytotic occurred during late summer and

¹ More detailed accounts of these tests are in "Fungicide-Nematicide Tests, Results of 1970 Tests", published by the American Phytopathological Society.

early fall. On 30 September, differences in leaf spot severity in plots of the different treatments were readily discernible. The disease severity ratings for the treatments on that date were as follows:

Treatment (oz active/acre)	Sugar /A(lb)	Leaf Spot Severity Rating (Index:1-10)
Thiabendazole	3.0	5731
Thiabendazole	6.0	5781
Tri phenyl tin hydroxide	2.4	5816
Cupric hydroxide	17.8	5442
Cupric hydroxide in oil	17.8 ^{1/}	4416
Check		4505
L.S.D. (.05)	859	0.4

Yields were commensurate with degree of disease control.

B. Tests with sulfides to control Rhizoctonia (Charles Lyons, Dow Chemical Co., Cooperator). In greenhouse tests, sulfides of potassium, phosphorus and ammonia were tested for efficacy in controlling Rhizoctonia infection of sugarbeet seedlings. The volatile materials were applied separately and combined and were compared with equivalent potassium, phosphorus and ammonia components in commercial fertilizer. The materials were applied to non-sterile field soil in flats at the rate of 100 lb/acre singly and at 83 lb/acre, combined. The potassium and phosphorus materials were mixed with the soil before planting. Ammonia compounds were applied as side-dressings immediately after the seed was planted. Each flat was infested with dried Rhizoctonia grain inoculum (5 to 30 c.c. per flat) in a shallow trench in the middle of the flat at right angle to the 5 rows of seeds (15 seeds per row). After seedlings had emerged, symptoms of disease appeared progressively at greater distances from the inoculum source. Disease severity ratings were assigned about 6 weeks after planting. The only treatments that reduced disease incidence and severity were the applications of ammonium sulfate and ammonium sulfide (Table 2).

III. Biology of Root Disease Fungi.

A. Aphanomyces cochlioides oospores. Studies were continued on the production and employment of Aphanomyces oospore inoculum. Oospores in abundance have been produced on various natural media, including decoctions of oatmeal, maize meal, sugarbeet leaves, Cruciferae leaves, pearl barley buckwheat groats and lima beans. Homogenized oatmeal broth (5 gm/liter) is the most satisfactory medium that has yet been found for oospore production with a vermiculite carrier. The pH of oatmeal broth was found to be close to 6.5, which is about optimum for oospore production. Attempts to change the pH of oatmeal-vermiculite medium from 7.3 to 6.5 with acid and appropriate phosphate buffers did not result in increased oospore production, however.

A. cochlioides isolates differed considerably in ability to produce oospores in vitro. Oospores produced by each of nine isolates ranged in

^{1/} Phytoxicity noted

number from 6.2 to 161.8/mm² (average = 71.8).

Dried oospore inoculum progressively showed less infectivity after one year of storage at 4°C as time increased. Never-the-less, oospores 3.5 years old incited infection of sugarbeet seedlings.

B. Pathogenicity of Rhizoctonia isolates. Studies on the ability of R. solani isolates from sugarbeet to parasitize other crops and weeds of the North Central region were continued. Seedlings of eleven species were grown in pots of soil infested separately with 19 isolates from sugarbeet roots and two isolates from sugarbeet foliage (foliar Rhizoctonia). The degree of infection of each isolate on each host was determined according to severity of damping off, root rot and lower stem rot. The 11 plant species differed considerably in susceptibility to the Rhizoctonia isolates and the isolates differed in aggressiveness on each host. The average infection ratings of each plant species, based on an index from 0 to 4, were as follows: tomato = 0.1; Amaranthus retroflexus = 0.2; sweet clover = 0.4; pepper = 0.6; sunflower = 0.6; cucumber = 0.8; turnip = 1.2; soybean = 1.5; cabbage = 2.2; sugarbeet = 3.3; navy bean = 3.4. The two foliar Rhizoctonia isolates were considerably more aggressive than the root isolates on all hosts except sugarbeet and navy bean, in which case they were about the same as the root isolates. The ranking of the isolates in order of aggressiveness was about the same on each host.

The Rhizoctonia isolates also differed in ability to incite root rot of older sugarbeets. Their ranking in order of virulence on older sugarbeets was essentially the same as their ranking on the 11 seedling hosts. The two foliar isolates, although very pathogenic on sugarbeet seedlings, caused no root or crown rot of older sugarbeets.

Table 1. Comparison of Rhizoctonia severity ratings of seven sugarbeet cultivars in greenhouse and in field inoculations.

Cultivar	Root rot severity ratings ^{a/}	
	Greenhouse ^{b/}	Field ^{c/}
SP691246-00	3.0	3.0
SP691247-00	3.2	5.3
SP691208-H0	3.7	5.7
SP671007-0	4.7	4.7
SP671008-0	4.7	5.0
SP691006-0	5.3	5.0
SP6912201-01	6.7	8.0

^{a/} Disease severity index = 0 (no symptoms) to 10 (dead).

^{b/} Average ratings based on separate inoculations with 6 R. solani isolates.

^{c/} Ratings based on 1970 field inoculation with mixture of 2 R. solani isolates.

Table 2. Results of greenhouse test to control Rhizoctonia infection of sugarbeet seedlings with ammonium sulfate and ammonium sulfide at 100 lb/acre.

Treatment	Disease severity rating ^{a/}	Plants surviving ^{a/b/}
		number
(NH ₄) ₂ SO ₄	2.1	8.4
(NH ₄) ₂ S	2.8	5.3
Control - inoculated	3.2	3.1
Control - uninoculated	0	13.0

^{a/} Results expressed as means of three flats, each with five rows of seedlings (15 seeds planted per row).

^{b/} Disease severity index = 0 (no symptoms) to 4 (dead).



Fig. 1. Differences in *Rhizoctonia* resistance between entries in *Rhizoctonia* nursery at East Lansing. The flagged row near center is line 691246-00 (FC701/4) with 6 cycles of selection for *Rhizoctonia* resistance at Fort Collins. To the right are plots of lines with no history of selection for resistance to *Rhizoctonia*.



Fig. 2. The effect of PCNB crown sprays in controlling *Rhizoctonia* crown and root rot. Control plot (second plot from left) is adjacent to plot sprayed with PCNB at 2 lb active/acre (third plot from left).

PHYSIOLOGICAL INVESTIGATIONS - 1970

F. W. Snyder

Germination & Emergence Studies

I. Seed Maturity: A second year of seed-maturity data in the greenhouse in Michigan has confirmed my 1969 report. I have defined physiological maturity of sugarbeet seeds as follows: With repeated harvests of "seeds" from the same plants, the seeds are physiologically mature when they first germinate at least 90%. In these studies the fruits were hand-processed, not soaked, and germinated on a moist blotter at about 70 F for 10 days. The fruits from which no seed germinated were cut open and corrections were made for no seed or partially developed seeds judged to be non-viable.

The ranges for 19 plants of a cultivar were as follows: Number of days from first bloom to physiological maturity, 33 to 73; number of days from first bloom to attain fruit color of commercial maturity, 40 to 67; approximate percentage of moisture at physiological maturity, 41 to 261% on dry weight basis or 38 to 75% wet basis; number of heat units required (base temperature 45 F as per TeKrony) from first bloom to physiological maturity, 820 to 1,100 (one plant required 1,700 heat units to attain 90% germination).

For the above listed attributes, individual plants within a cultivar may differ more than the averages between cultivars. (See my 1969 report also averages of TeKrony (4). As long as no specific selections are made for these attributes, the large variations may be expected to occur in the cultivars. Thus far, no single precise criterion has been found to guarantee physiological maturity of the seed from each plant at harvest.

II. Emergence: Snyder and Filban (3) suggested using fine sand (<1 to 0.1 mm) for determining emergence potential of seeds. The possibility of compaction of the moist sand which could affect the percentage of emergence was cited. The need to weigh the sand and add a specific amount of water also was a time-consuming detail.

A simpler, ~~more~~ rapid technique follows: Washed gravel (2 to 5 mm mix) is autoclaved. For the emergence test, the gravel is immersed in tap water and just before placing in a plastic box, it is drained briefly to remove most of the water that runs off. About a ½ in. of gravel is placed in the box and leveled; the dry "seeds" are placed on the gravel and covered with moist gravel to a depth of 1 in. over the "seeds". The box is covered to minimize moisture loss. No weight or volume measurements are needed and no moisture need be added for a 14-day emergence test. By removing the emerged seedlings and re-autoclaving, the gravel can be used indefinitely. The floating fruits from previous tests may be removed when the gravel is immersed to wet it.

With this simplified technique, emergence for various seedlots has ranged from 39 to 95% where the corresponding germination percentages ranged between 77 and 99. As the germination percentages decreased, the emergence percentages decreased more steeply.

Leaf-area Accretion Studies

According to Ulrich (5), top growth of 5-week old sugarbeets is not increased by light intensities greater than 4,000 ft-c and by greater than about 2,000 ft-c for 17-week old plants. Root growth continued to increase at 5,000 ft-c, thus light saturation for root growth was not achieved (5).

I. Growth Chamber: Plants were grown in 16 oz thermal containers in vermiculite. Mineral nutrient solution was applied daily. Light intensities ranged between 2,000 and 2,500 ft-c, except for one experiment. Light duration was 14 hr per day. Except for temperature studies, the daily temperature was 77-61 F and synchronized with the light-dark cycle. Comparative rates of accretion were based on the period 4 to 23 days after emergence. The leaf areas of plants, measured at intervals, were plotted on semi-log paper as a straight line and its slope indicated the rate of area accretion.

A. Plant responses: Average leaf area per plant, standard deviation, and coefficient of variation were calculated for 9 groups (12-30 plants per group) comprising 6 varieties in 7 experiments. Coefficients of variation ranged from 7.6 to 18% with 7 groups ranging between 11 and 16%. Hammond's doubled-haploid, SP 6600 had a C.V. of 11% and appeared more uniform. It is not possible to determine what portion of the variation is caused by plant to plant genetic differences and what portion by micro-environmental variations, but leaf areas differed by 4 days after emergence and were maintained until the end of the experiments.

In two sets of 5 comparative experiments, the cultivar US H20 had a nearly uniform rate of leaf area accretion and 6 cultivars had very similar rates of accretion. Whereas the average rates of leaf area accretion for cultivars were very similar, the extreme rates of accretion among individual plants within a cultivar appear to be significantly different. For 5 of the 6 cultivars, the leaf areas of individual plants deviated at least 2 standard deviations from the mean when harvested between 18 and 26 days after emergence.

Two cultivars which differed in root yield (average of 18% in 4 agronomic evaluation tests) under field conditions were grown together in a growth chamber for 23 days after emergence. The cultivar with the highest root yield had 12.7 to 19.8% greater leaf area for four measurements between 6 and 23 days.

B. Environmental effects: US H20 was grown at mean temperatures of 70, 56, and 52 F. The rate of leaf area accretion was slightly lower at 56 than at 70, but significantly lower at 52 F. When the temperature was raised from 52 to 61 F, the rate of accretion was very similar to that attained on the higher temperatures. These results and other observations suggest that the rate of leaf area accretion may not be uniformly temperature sensitive, since a marked decrease in the rate of accretion occurred only between 56 and 52 F. The temperatures 70 and 52 F closely approximate a 10 C difference. The rate of leaf area accretion was altered 2-fold by this interval.

The rate of leaf area accretion of US H20 in the growth chamber was compared in full light and with half of the fluorescent and incandescent lights shut off. The reduced intensity of light did not alter the rates of accretion enough to draw any conclusion without further experiments.

In the growth chamber the rate of leaf area accretion and total leaf area per plant were increased significantly by increasing light intensity from 1,000 to 2,000 ft-c and also by increasing the CO_2 in the air from 300 to 800 ppm or more (Unpublished study in 1964 by Snyder and Wittwer).

II. Outdoors versus Growth Chamber: During June, July, and August US H20 was grown outdoors (10 in. pots, vermiculite) at mean temperatures approximating 70 F and in sunlight. Light intensity (ft-c) multiplied by duration (hr) can be expressed as average number of ft-c per day for growth chambers. Radiation from the sun in Langleys ($\text{cal cm}^{-2} \text{ min}^{-1}$) can be summated each day and converted to an approximate average ft-c per day using the formula of Reifsnyder and Lull (1). Full light in the above growth chamber experiments approximated 30,000 ft-c per day and outdoors 60,000 and 64,000 for the two experiments.

Rates of leaf area accretion and total leaf area per plant for the two outdoor experiments were very similar to those in the growth chamber, even though the light per day was approximately double that in the growth chamber. For the first 21 to 24 days after emergence, doubling the ft-c of light per day under the outdoors conditions also did not increase the dry matter accumulation (of the shoot) per unit leaf area over that attained in growth chamber experiments. (Similar results were obtained for maize for the first 14 to 18 days outdoors.) After about 24 days the rate of leaf area accretion tended to decrease while the rate of dry matter accumulation per unit leaf area increased, similar to leaf area results reported previously (2).

III. Summary: 1. Within 3 weeks after emergence, plants within a sugarbeet cultivar may deviate by at least two standard deviations from the mean leaf area for the group, even when grown in the growth chamber with minimal environmental variation.

2. Results for sugarbeet thus far suggest that rates of leaf area accretion do not respond uniformly to changes in either light or temperature. Rates of change seem to be much smaller and thus harder to detect when changes of given magnitude are made near the optimum for the factor as compared with the rates of change observed farther from optimal conditions. For example, when the temperature was reduced from 70 to 56 F the rate of leaf area accretion decreased slightly, but the rate decreased sharply from 56 to 52 F. When light was reduced from about 60,000 ft-c per day to 30,000, a change in the rate of leaf area accretion could not be detected with certainty, but reducing the light intensity in the 1964 study from 2,000 to 1,000 ft-c clearly decreased the rate.

Enzymes in Sugarbeet Leaves

N. E. Tolbert (Biochemistry Dept., Michigan State Univ.) and some of his research group have been using sugarbeet leaves for enzyme studies. Recently they have been working with the enzymes, 3-phospho-glyceric acid

phosphatase and phospho-glycolate phosphatase which cleave the high energy phosphate to form glyceric acid and glycolate, respectively. Phosphoglyceric acid is an early product of photosynthesis and thus an intermediate in sucrose synthesis. Glycolate is involved in photorespiration.

In studying the effects of some of the major environmental and internal plant factors on enzyme activity, I am collaborating with Tolbert by growing the plants under the desired environmental conditions. As yet, no results are available.

Translocation Studies

The technique of selecting closely matched leaves on a sugarbeet plant, using one as a control while treating one or two others with chemicals which may alter the rate of translocation, has not given consistent data as had been anticipated. As a result, a relatively large number of replications were required to obtain statistically significant results and the assumed economy of the technique was largely lost. The variability also increased the difficulty in establishing the effect of a chemical on translocation.

In the 1970 tests, exposure to $^{14}\text{CO}_2$ and translocation were limited to 30 minutes. N-6 benzyladenine, particularly with repeated applications, retarded translocation of photosynthate out of the blades of plants either on adequate nitrogen or deficient nitrogen (45 replications, statistically significant at 1% level).

After rechecking the data, kinetin applications retarded translocation out of the blade, but not quite significantly at the 5% level, contrary to my 1969 report. Additional replications probably would have made it significant, however.

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PHYSIOLOGICAL AND HISTOLOGICAL STUDIES ON SUGARBEETS^{1/}

R. M. Cressman^{2/}

I. Diffusion of Sugar from Sugarbeet Tissue

Studies regarding factors affecting the rate of diffusion of sugar from sugarbeet tissue have been continued. Diffusion versus phosphate concentration has been studied with other varieties. The effect of pH on diffusion has been studied using more homogeneous tissue samples. The effects of several other salts have been examined and the effect of temperature on diffusion rates and on total extraction have been studied.

The procedures used have been similar to those described in my 1969 Report (Sugarbeet Research 1969 Report). However, tissue sections which have been compared have been taken from the same cylinder of tissue or from cylinders taken from radially-adjacent parts of the beet, when applicable.

Phosphate concentration.--Additional data for diffusion after 6 hours in various concentrations of $\text{KH}_2\text{PO}_4:\text{K}_2\text{HPO}_4$ (1:1) are listed in Table 1. Discs placed in 0, 10^{-3} , 0.1, 0.3, & 0.5M solution were cut consecutively from the same vertical core. Discs in alternate concentrations were consecutive from an adjacent core. By using this method of selecting discs, variation was less than had previously been encountered. Diffusion decreased with increasing salt concentration up to 0.2 M. At higher concentrations, the rates of diffusion are similar in magnitude, but variable. Previous tests had indicated that 0.2 to 0.25 M phosphate was isotonic to sugarbeet tissue. Thus at the higher salt concentrations, the variation in diffusion rates may be a result of plasmolysis of the cells.

Six different varieties of young beets (about 2 months old) were tested in distilled water and in 0.1 M NaCl. The results are given in Table 2. Two of the commercial beets had higher diffusion rates than the other two and the fodder beets, Ovana and A58-5, had lower rates than the commercial beets in both solutions. The results indicate that there may be some differences among varieties, but, because of inherent variation, extensive testing will be necessary to determine if this is so.

^{1/} This research was conducted in cooperation with the Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota.

^{2/} Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, Fargo, North Dakota.

Table 1. Sugar diffused after 6 hours from discs of sugarbeet tissue in phosphate solution. Beet variety Am #3 hybrid N from two locations.

Location	Sugar diffused after 6 hours (mg sugar/g beet)									
	PO [≡] Conc. (Molarity)									
	0	10 ⁻⁴	10 ⁻³	10 ⁻²	.1	.2	.3	.4	.5	1
Casselton	18.2	12.9	8.2	8.1	5.7	3.3	3.9	3.5	4.6	2.4
	14.6	14.3	9.4	5.2	6.0	3.9	5.8	4.8	5.8	4.4
	14.1	14.5	8.8	6.0	4.0	3.0	3.7	4.7	4.6	4.3
Average	15.6	12.9	8.8	6.5	5.2	3.4	4.5	4.3	5.0	3.7
Fargo	11.4	13.8	5.9	7.0	3.2	3.3	3.6	3.8	3.7	3.4
	4.5	4.1	2.8	3.3	2.9	2.4	3.5	3.2	3.7	2.7
	12.9	10.7	7.2	7.5	3.3	3.1	2.9	3.5	3.9	2.9
Average	9.6	9.5	5.3	5.9	3.1	2.9	3.4	3.5	3.7	3.0
Overall Av.	12.6	11.2	7.0	6.2	4.2	3.2	3.9	3.9	4.4	3.4

Table 2. Sugar diffused after 6 hours from discs of tissue from 6 varieties of beets.

NaCl Conc. (Molar)	Variety	Sugar diffused after 6 hrs (mg sugar/g beet)			
		Experiment			Average
		1	2	3	
0	Am 3 Hyb N	10.8	8.2	9.9	9.6
	Am 3 Hyb A	9.6	8.6	10.8	9.7
	Am 3 Hyb T	14.4	13.8	24.0	17.4
	IS 951	31.0	16.1	17.2	21.4
	Ovana (Fodder)	5.6	7.1	3.9	5.5
	A58-5 (Fodder)	4.3	4.7	3.1	4.0
	Average				11.3
0.1	Am 3 Hyb N	4.1	2.8	3.5	3.5
	Am 3 Hyb A	2.9	3.8	3.2	3.2
	Am 3 Hyb T	5.0	3.4	5.7	4.7
	IS 951	8.5	5.3	4.2	6.0
	Ovana (Fodder)	2.0	3.0	2.4	2.5
	A58-5 (Fodder)	1.9	1.9	1.9	1.9
	Average				3.6

Other salts.--Diffusion of sugar into solutions of NH_4NO_3 , H_3BO_3 , and MgSO_4 adjusted to a pH 6.5 is listed in Table 3. For the latter two the results are similar to diffusion into phosphate solutions in that the rate of diffusion decreased with increasing salt concentration. In other words these ions do not appear to affect the rate of diffusion. The nitrate ion reacts in the phenol-sulfuric acid method of analysis and the results for this salt are thus without real meaning. The effect of the ammonium ion must be tested in another form, and the effect of the nitrate ion cannot be tested by the present procedure. NaCl has been tested previously and has been used extensively in place of the phosphate salts, since no differences in effect were observed.

The results indicate that the protective effect of the salt concentration to diffusion of sugar is probably ionic in nature rather than the effect of a specific ion. It would be of interest, however, to see if any ion has an effect of increasing diffusion.

Table 3. Effect of some salts on diffusion of sugar from sugarbeet tissue.

Salt	Diffusion after 6 hours (mg sugar/g beet)					
	Conc. (Molar)					
	.3	.1	10^{-2}	10^{-3}	10^{-4}	0
NH_4NO_3	-	-	16.75	16.23	12.98	13.07
H_3BO_3	3.20	4.10	5.32	8.41	11.62	12.70
MgSO_4	5.34	6.40	7.03	8.36	8.86	9.96
Average	4.27	5.25	6.18	8.39	10.24	11.33

pH.--Hydrogen ion concentration was maintained by the ratio of KH_2PO_4 to K_2HPO_4 . The method of selecting the sections of tissue gave more uniform results than were previously obtained. Two radially-adjacent cylinders were cut from a slice of beet and consecutive sections from one cylinder were placed in the alternate solutions listed in Table 4. The data in this table are the averages of 3 beets of each of 6 varieties.

The rate of diffusion was minimal at pH 6.5 but the variability among beets was less at pH 7. In general, variability and rates of diffusion were higher at the extremes of pH than near neutral. Thus, as the pH of the solution deviates from about 6.5, sugar diffuses more rapidly from the cells but the rate is also more erratic. Again, there are apparent differences among varieties, but more numerous tests would have to be made to confirm this condition.

Table 4. Effect of pH on diffusion of sugar from sugarbeet tissue.

Variety	Diffusion after 6 hours (mg sugar/g beet)									
	pH									
	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
Am 3 Hyb N	18.8	13.4	9.6	6.6	6.3	5.8	7.4	9.1	14.4	16.4
Am 3 Hyb T	22.5	13.0	12.3	8.0	7.6	6.9	8.1	8.9	11.2	11.4
Am 3 Hyb B	11.0	8.3	5.7	5.7	4.5	6.0	6.6	10.4	9.6	11.5
Am 3S	10.5	9.2	5.5	7.1	4.5	5.8	6.8	8.7	10.4	13.4
Zwannpoly	3.6	4.1	3.2	3.5	3.2	3.9	3.4	3.8	4.6	4.7
IS 93	6.5	5.1	4.2	4.2	3.3	4.9	3.7	5.3	5.8	6.9
Average	12.2	8.9	6.7	5.8	4.9	5.6	6.0	7.7	9.4	10.7
Stand. dev.	8.3	4.2	3.8	2.0	2.1	1.3	2.6	3.4	4.9	5.7
CV	68.2	47.8	55.7	33.6	42.6	23.4	42.5	43.8	52.8	52.9

Temperature.--The effect of temperature on diffusion of sugar from beet tissue and also on total extraction of sugar was investigated. Table 5 shows the amount of sugar diffused at various temperatures and at various times and in various salt concentrations. The rate of diffusion increased with increasing temperature. Salt concentration had a protective effect on the diffusion rate. In 0.5 M NaCl, the rate of diffusion did not increase rapidly until the temperature was above 50°, whereas in distilled water, the rate of diffusion was increasing rapidly at 35°. In 0.1 M solution, the rapid increase in diffusion rate occurred between 35 and 40°.

At the higher temperatures which cause complete extraction within a short time, a slight protective effect by salt concentration was also evident (Table 6). At 85°, extraction occurred within 10 minutes at all concentrations of NaCl. At 75°, extraction occurred within 15 minutes in distilled water but within 20 minutes in 0.5 M NaCl. At 65°, 20 minutes was necessary for complete extraction in distilled water, but in 0.5 M NaCl, 25 minutes was necessary. The salt-temperature interaction was more evident at intermediate temperature ranges, 45 to 65° as shown in Table 7. At the higher salt concentrations, higher temperatures were necessary to extract the sugar.

Table 5. Effect of temperature on diffusion of sugar at several salt concentrations (mg sugar/g beet).

Solution	Time (hr.)	Series	No. of reps.	Temperature (°C)									
				25	35	40	45	47	50	53	55	60	
Distilled water	½	A	4	4.84	11.7		32.7					88.9	
		B	2			30.2			113.2				146.6
	1	A	4	7.61	21.5		54.6					121.4	
		B	2			62.7			143.7				151.1
	1½	A	4	9.51	29.7		70.5					131.4	
		B	2			90.9			148.9				155.1
	2	A	4	12.3	37.0		80.8					134.2	
		B	2			113.4			157.7				149.4
	2½	A	4	13.3	43.6		96.0					132.2	
		B	2			126.9			154.4				152.1
.1 M NaCl	½	C	4	2.65	4.69		10.4					40.3	
		D	2			8.85			76.7				165.2
	1	C	4	3.44	4.88		24.6					94.8	
		D	2			31.2			145.1				166.9
	1½	C	4	4.27	6.62		45.1					127.3	
		D	2			49.4			164.3				169.1
	2	C	4	4.54	8.64		64.7					138.5	
		D	2			74.1			166.9				168.9
	2½	C	4	5.01	10.7		84.3					138.4	
		D	2			99.6			169.4				166.2

Table 5. (Cont.)

Solution	Time (hr.)	Series	No. of reps.	Temperature (°C)										
				25	35	40	45	47	50	53	55	60		
.5 M NaCl	$\frac{1}{2}$	E	4	4.01					10.3		17.7	79.3		
		F	2					8.86	11.7	14.2				
		G	2						14.6		42.4	169.6		
		H	2								7.61			
	1	E	4	4.07	4.26		5.57		14.8		32.8	133.9		
		F	2	6.05				13.5	17.7	21.5				
		G	2						18.7		123.4	182.0		
		H	2	4.50	4.92		6.81				12.1			
	$1\frac{1}{2}$	E	4	5.65					16.8		52.3	132.3		
		F	2					12.8	22.2	27.4				
		G	2						23.2		168.4	183.7		
		H	2	5.11	5.07		7.07				18.6			
	2	E	4*	6.26					21.6		78.4	139.4		
		F	2					14.8	27.1	42.5				
		G	2						28.2		173.7	182.7		
		H	2	4.59	6.06		7.48				24.4			
	$2\frac{1}{2}$	E	4*	6.85					25.9		105.9	138.9		
		F	2					-	-	-				
		G	2						33.2		173.9	182.9		
		H	2	5.27	5.01		8.28				38.4			

*Only 3 replicates at 25°.

Table 6. Extraction of sugar from beet tissue in relation to temperature and salt concentration (mg sugar/g beet).

NaCl Conc. (Molar)	Temp. (°C)	Number of reps.	Time (Minutes)									
			5	10	15	20	25	30	35	40	45	
0	65	2	93.4	131.0	144.3	155.1	153.2	154.3	161.5	160.8	156.0	
0	75	1	115.5	146.4	159.9	155.0	154.3	160.8	169.3	156.0	159.3	
0	85	1	122.7	151.8	161.6	161.3	157.0	158.8	160.5	158.3	169.1	
.01	70	4	71.6	95.4	108.5	144.9	117.4	119.8				
.01	70	4	80.1	103.9	115.3	121.4	123.3	124.6	127.4	128.2		
0.1	65	2	81.9	130.2	150.2	156.3	161.9	162.4	161.4	164.5	162.7	
0.1	75	1	122.7	149.4	160.2	167.5	164.4	172.2	169.0	167.1	167.9	
0.1	85	1	125.3	152.8	160.4	166.4	167.3	167.1	164.4	163.5	160.6	
0.5	65	2	66.9	120.8	156.5	163.6	173.2	175.5	174.9	176.5	177.1	
0.5	75	1	113.9	154.3	168.9	178.6	177.6	178.6	178.4	175.2	181.9	
0.5	85	1	116.9	149.4	176.2	176.5	180.2	177.6	178.5	177.6	177.1	

Table 7. Extraction of sugar from beet tissue at intermediate temperatures (mg sugar/g beet).

NaCl Conc. (Molar)	No. of reps.	Time (hr.)	Temperature (°C)		
			45	55	65
0	4	$\frac{1}{2}$	47.0	124.8	158.1
		1	86.8	157.3	159.9
		$1\frac{1}{2}$	118.2	165.1	163.4
		2	137.1	162.9	158.9
0.1	3	$\frac{1}{2}$	21.9	79.9	165.6
		1	52.2	139.8	158.5
		$1\frac{1}{2}$	86.4	157.8	169.0
		2	113.7	162.2	166.8
		$2\frac{1}{2}$	132.8	159.6	165.7
0.5	3	$\frac{1}{2}$	9.8	67.8	178.1
		1	12.0	140.2	186.5
		$1\frac{1}{2}$	13.8	174.4	184.8
		2	15.4	176.5	185.5
		$2\frac{1}{2}$	20.6	179.2	190.0

II. Histological Analyses and Observations

Histological procedure.--The procedure for preparing slides of sugar-beet tissue in which the sugar is precipitated with $\text{Ba}(\text{OH})_2$ in methanol has been investigated further for improvements. Methods of preparing the tissue and in the timing in the several reagents, plus other incidental procedures have been varied. The solubilities of sucrose, $\text{Ba}(\text{OH})_2$, BaCO_3 , and barium saccharate in the reagents used have been determined for use in analyzing the procedure. Although the results have allowed some refinement of the technique, more work needs to be done before the best procedure can be reported and the slides can be made permanent with consistently good results.

Ring analyses.--The distribution of sugar among the rings and the interzones of various types of beets was determined by microchemical analysis as described in my 1969 Annual Report (Sugarbeet Research 1969 Report). Included were commercial beets and fodder beets from both the field and greenhouse. Also included were some commercial beets which had grown in the greenhouse and were then starved by placing them in a dark cabinet until new growth had ceased. The results of the zone analyses are given in Table 8. Histological observations were in general agreement with the chemical analyses.

The commercial beets showed a distribution of sugar similar to that previously reported and whose average is listed in the first column of Table 8. The inner interzones have less sugar than the ring tissues. The fodder beets show this same pattern but the relative differences which were observed were greater; the first 2 interzones were particularly low in sugar. The fodder beets contained fewer rings, much broader interzones, less-developed vascular bundles and larger cells (especially in the interzones) than did the commercial beets. Fodder beets grown in the greenhouse had higher sugar concentrations, less-developed vascular bundles, and smaller cells in the interzones than those grown in the field. The greenhouse fodder beets were older and much smaller than those from the field. The obvious inference is that, in fodder beets, more of the sugar is converted into growth than in commercial beets and that the restricted growth of fodder beets in pots allows more sugar to be stored than in the field fodder beets, which apparently did not reach their full storage potential. Histological observations on the sugar concentrations among cells within and among beets suggests that, for a given volume of tissue, larger cells store less sugar than smaller cells. This thesis is derived from the differences in sugar concentrations between rings and interzones, between fodder and commercial beets, and also from the differences among the cells within an interzone.

In the starved beets, the sugar concentration was substantially reduced in all tissues. At the time the beets were removed for analysis, the top growth of the beet was dying and the beets were deteriorating and rotting. Even in beets which were mostly rotted, and thus not analyzed, but examined histologically, some sugar was still present.

Table 8. Sugar content of the rings and interzones of beets of several varieties and cultural conditions.

Zone	Commercial Beets			Fodder Beets				Starved Beets *				
	Previous average	Field	3S	Greenhouse		Field		1	2	3		
				T	N	Ovana	A-58				Ovana	A-58
C	13.7	21.5	18.4	18.5	7.4	4.8	14.1	13.5	13.5	5.0	12.4	6.6
I-1	10.2	17.3	15.9	14.5	4.6	3.2	9.9	12.5	8.4	4.5	13.0	8.5
R-1	13.8	20.5	18.9	16.7	6.9	6.0	13.8	13.4	13.0	4.6	14.0	7.3
I-2	10.8	18.8	18.3	16.9	4.3	2.7	8.8	9.8	8.8	4.4	13.8	8.3
R-2	13.7	20.6	18.9	17.4	6.9	5.5	13.0	13.5	11.9	4.8	13.8	6.8
I-3	11.0	18.7	19.2	17.8	5.0	3.4	10.2	12.1	11.4	4.5	14.1	7.5
R-3	13.7	20.8	20.2	17.7	7.2	5.5	13.0	13.2	13.3	4.8	13.4	6.5
I-4	11.7	19.8	19.6	17.7	6.2	4.0	12.3	13.2	12.5	4.5	13.1	3.8
R-4	13.5	21.1	19.3	18.1	6.9	4.0	12.9	13.3	12.5	4.9	12.6	4.9
I-5	12.6	20.9	18.5	17.3	7.1		13.2			4.4	11.6	
R-5	13.8	21.2	18.7	17.4	6.8	5.0	12.3	12.3	11.7	5.0	11.2	4.0
I-6	13.2	21.6	19.0	17.7	6.8					4.9		
R-6		21.1	18.3	17.4	7.3					5.4	11.0	2.4
I-7			17.8									
R-7		21.2	17.8	13.6						5.5	10.6	
R-8		20.2	16.8							5.6	7.5	
R-9			14.2							4.8		

* Commercial beets grown in the greenhouse.

These observations together with the comparison of the commercial versus fodder beets indicates that the sugar in all parts of the beet is nearly equally mobile, and that large differences in sugar concentration among beets is not a consequence of storage in certain tissues. The fact that the starved beets died before the sugar was depleted is also of considerable interest and supports the hypothesis that a large portion of the sugar stored in the beet is relatively immobile, a concept which is also compatible with the results of the diffusion experiments and the concept of an active mechanism of sucrose storage.

III. Storage Quality in Relation to Phosphate Fertility

In 1969, 2 varieties of sugarbeet seed were planted at 4 levels of phosphate fertilization. Beet quality was determined at harvest and after 2 lengths of storage periods. Original soil phosphate averaged 18 lbs. of P per acre, a medium rating for the soil. Treatments included 0, 30, 60, and 90 lbs. of P per acre in a split-block design replicated 4 times.

In October, 60 feet of row were harvested from each plot, yield determined, and the samples split into 3 approximately equal portions. One part was pulped immediately; the other 2 were stored in a cold room at about 4°C. The second part was analyzed in mid-January; the third part, at the end of March.

The data are given in Table 9. Sucrose percentage was only slightly less in January, but had dropped sharply by March. Raffinose and kestose increased considerably by March in all instances. Phosphate level did not appear to have any obvious effect.

Acknowledgement.--Appreciation is expressed to the American Crystal Sugar Company for supplying the seed and performing the analyses.

Table 9. Quality factors of sugarbeets at 4 phosphate levels after 3 storage periods, 1969-70 results.

Storage			Dehydration			Raffinose			Kestose			PO4			Na			K			Amino N			Impurity Index		
Phosphorous		period	Yield		Sucrose	Dehydration	Raffinose		Kestose		PO4		Na		K		Amino N		Impurity Index							
lbs.	P/A	weeks	T/A	% (Or.Wt.)	%	% DS	% DS	% DS	% DS	% DS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
Variety: American #3 Hybrid N																										
0		0	15.6	18.9		.70		.27		104.9	502	2260	192		495											
		11.5		18.6	10.9	.90		.86			492	2475	264		506											
		22.5		17.0	20.0	2.30		2.35			518	2608	282		525											
30		0	14.8	18.1		.80		.16		122.4	508	2562	193		560											
		11.5		18.1	10.2	.97		.40			440	2358	221		478											
		22.5		16.9	16.5	1.88		2.42			492	2692	268		552											
60		0	17.0	18.8		.75		.23		129.9	428	2445	192		508											
		11.5		18.1	7.9	.83		.50			440	2362	253		507											
		22.5		18.3	14.5	1.11		1.44			528	2430	266		496											
90		0	17.8	18.6		.76		.19		142.2	470	2422	232		540											
		11.5		18.2	9.5	.72		.50			480	2472	278		528											
		22.5		16.6	17.0	1.63		3.08			495	2692	317		582											
Variety: American #3S																										
0		0	17.2	18.4		.57		.16		101.9	558	2338	236		552											
		11.5		18.1	8.9	.81		.50			468	2115	215		455											
		22.5		16.4	18.8	2.86		2.83			542	2545	333		577											
30		0	17.9	18.4		.76		.24		121.4	612	2318	189		535											
		11.5		17.3	14.9	.81		.34			638	2258	247		511											
		22.5		16.2	17.1	1.65		1.72			690	2428	392		636											
60		0	16.5	18.7		.79		.22		104.8	570	2365	240		553											
		11.5		17.7	11.5	1.05		.42			578	2380	260		528											
		22.5		16.9	14.3	2.04		2.28			625	2558	276		574											
90		0	17.2	18.0		.74		.13		132.8	590	2342	186		544											
		11.5		17.6	8.6	1.30		.68			585	2305	218		523											
		22.5		15.6	17.6	1.96		1.92			588	2762	310		638											

IV. The Effect of Temperature and Depth of Planting on Germination of Sugarbeet Seed

Sugarbeet seed was planted in greenhouse potting soil in six-inch pots and placed in growth cabinets at 4 temperatures. In the first set of experiments, variety Am #3S was used. Twenty-five seeds were planted in each pot at depths of 2, 4, 6, 8, or 10 cm. Four pots of each depth were planted and placed in growth cabinets at 12, 17, 22, and 27°C. In the second set of experiments, variety Am #3 Hybrid T was used and the seeds were planted at 2, 4, 6, and 8 cm. Emergence was recorded daily until no further emergence occurred. The averages are given in Tables 10, 11, and 12. Each figure is the average of 4 replicates except where specified.

There was little difference in total emergence between the 2 and 4 cm. treatments. Emergence was progressively less at greater depths with negligible emergence occurring at 10 cm. Emergence was slightly less at 12°C than at the higher temperatures. At the greater depths, emergence was also less at the highest and lowest temperature than at the 2 intermediate temperatures. Emergence of variety Am Hybrid T was reduced more by deeper planting than Am #3S. Post-examination revealed that, at the greater depths, many seeds germinated but did not emerge.

The time for emergence was longer with progressively lower temperatures and this lengthening effect was greater at the greater depths. More variation occurred at the greater depths and was probably due to variability in compaction of the soil, a factor which is hard to control.

Under the conditions of this experiment, emergence is significantly reduced at depths greater than 4 cm and is even reduced at this depth at a temperature of 12°C, a temperature which is not particularly low for soil temperature during the usual planting time in North Dakota.

Table 10. Effect of depth of planting and temperature on emergence of sugarbeet seedlings, averages of 4 replicates.

Variety	Temp. °/C	Emergence (%)				
		Depth of Planting (cm)				
		2	4	6	8	10
Am 3S	27°	74	69	59	35	5
	22°	77	79	66	46	9
	17°	77	73	62	34	8
	12°	65	63	52	24	1
	Average	73	71	59	34	6
	St. Dev.	6.0	6.8	5.7	9.0	3.4
Am Hyb T	27°	69	64	50	18	
	22°	74*	64*	48*	22*	
	17°	67	66	48	23	
	12°	60	48	38	14	
	Average	67	60	46	19	
	St. Dev.	6.8	9.3	9.4	11.4	

* Only 3 replicates

Table 11. Effect of temperature and depth of planting on time to emergence of sugarbeet seedlings, variety Am. #3S. Averages of 4 replicates.

Temp. Depth (°C) (cm)		Emergence %																								
		Days from Planting																								
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
27°	2	27	52	64	68	69	70	72	72	73	74	74	74	74												
	4	7	32	54	62	65	66	67	67	67	68	68	69	69												
	6	1	14	36	47	51	54	55	56	57	58	59	59	59												
	8		2	10	23	27	30	32	33	34	34	35	35	35												
	10				2	2	3	4	4	4	5	5	5	5												
22°	2	3	32	56	67	72	74	75	76	76	76	77	77	77												
	4		12	42	61	69	73	75	78	78	79	79	79	79												
	6		1	18	41	52	57	61	63	65	65	65	65	65												
	8			1	9	22	32	38	41	43	45	46	46	46												
	10				1	2	4	5	6	7	8	8	9	9												
17°	2		7	37	59	68	71	72	74	75	76	76	77	77	77	77	77									
	4		1	8	25	48	59	64	68	69	70	70	72	72	73	73										
	6				3	14	30	41	50	54	57	58	61	62	62	62										
	8					2	6	10	16	22	26	29	31	32	33	34										
	10						1	2	3	4	6	7	8	8	8											
12°	2						6	15	27	38	46	52	57	59	61	62	63	63	64	64	64	64	65	65		
	4							1	8	15	26	36	44	50	54	55	57	58	59	60	60	61	61	61		
	6									1	4	9	16	22	30	34	38	41	44	47	48	49	50	51		
	8											1	1	3	3	5	9	12	16	17	19	21	22	23		
	10																			1	1	1	1	1		

Table 12. Effect of temperature and depth of planting on time to emergence of sugarbeet seedlings, variety Am. #3 Hybrid T. Averages of 4 replicates.

Temp. Depth (°C) (cm)	Emergence %																									
	Days from Planting																									
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
27°	2	30	51	62	65	66	67	68	68	68	68	69	69	69	69											
	4	6	27	48	58	61	62	63	63	64	64	64	64	64	64											
	6		11	27	40	47	48	49	49	50	50	50	50	50	50											
	8		1	5	9	11	14	16	17	17	18	18	18	18	18											
22° *	2		36	57	68	72	73	74	74	74	74	74	74	74	74											
	4		12	31	48	57	57	59	59	60	60	61	61	61	61											
	6		1	8	31	45	49	50	51	52	52	52	52	52	53											
	8				2	10	17	19	21	25	25	26	27	27	27											
17°	2				25	44	59	63	65	66	66	67	67	67	67	67	67									
	4				6	27	50	58	61	64	64	65	66	66	66	66	66									
	6					2	15	24	33	39	42	44	45	47	47	47	47									
	8						3	7	10	14	17	18	20	21	21	22	22									
12°	2						1	6	35	44	48	51	53	55	56	57	57	58	58	56	59	59	59	59		
	4								9	18	27	31	38	40	41	43	45	46	47	47	47	47	48	48		
	6										3	6	12	18	22	27	29	33	36	36	37	38	38	38		
	8												1	1	4	7	7	9	11	12	12	12	12	13		

* Only 2 replicates included

SEEDLING DISEASES, RED RIVER VALLEY

W. M. Bugbee

SEED TREATMENT.--Fourteen fungicide treatments were applied to sugarbeet seed and planted on June 3, 1970. This was the third year for sugarbeets in this plot, however seedling diseases did not develop. Stand counts from treatments were not statistically better than the untreated check.

Seedling diseases were present, especially in the southern half of the valley. Their prevalence was difficult to estimate because of seedling damage that resulted from heavy rains.

SOIL FUNGICIDES.--Protection against seedling diseases can be extended to 4-6 weeks after planting with the use of soil fungicides. Certain formulations contain a fungicide-insecticide combination. This gives the farmer the unusual opportunity to combat seedling diseases and early season insects in one application. Certain sections in the north of the valley have a root maggot problem. They are slowly spreading into southern areas where seedling diseases also are present. One purpose of this test was to observe the compatibility of a commercially available fungicide-insecticide combination.

Plots were planted at Glyndon, Minnesota and Cavalier, North Dakota. Granule formulations of fungicides or fungicide-insecticide combinations were applied to the open furrow between the seed drop tube and press wheel. Stand counts were taken 30 days after planting.

Seedling diseases did not develop adequately on these particular plots. The data in Table 1 show that stands at Cavalier were lower than at Glyndon. This was due to extremely wet soil at planting and root maggot damage.

Phytotoxicity was apparent in two treatments at Glyndon. The stand count was significantly reduced in the Daconil-Dexon treatment. Although Terraclor Super-X and Di-Syston alone gave satisfactory stands, the combination was toxic at both locations. Di-Syston is one insecticide recommended by the North Dakota Experiment Station for root maggot control. Other non-commercially available combinations will be tested.

Table 1. Granular soil fungicides applied to furrow at planting.

	Lbs/A Active	Glyndon, Minn.		Cavalier, N.D.	
		Stand	Tons/A	Stand	Stand
Daconil + Terrazole	1.6 +.4	77 a	13.4 a	52 a	
Daconil + Dexon	1.6 +.4	58 c	10.4 b	53 a	
Terraclor Super-X	1.6 +.4	77 a	10.7 ab	47 a	
Terraclor Super-X + Disyston	1.6 +.3 +.4	48 d	9.0 b	38 b	
Disyston	.4	66 bc	9.8 b	50 a	
Check	--	70 ab	10.7 ab	53 a	

PECTOLYTIC ENZYME PRODUCTION BY
SUGARBEET STORAGE ROT ORGANISMS ^{1/}

W. M. Bugbee

The many fungi and bacteria that decay storage roots of sugarbeets account for considerable loss of sucrose. These micro-organisms must produce several cell wall degrading enzymes in order to penetrate and invade host tissue. Pectolytic enzymes are important in this regard because of their ability to depolymerize the intercellular pectic materials of plant tissue.

Some fungi commonly infect storage roots in the field and their decay activity continues or even increases after harvest. Four of these fungi are included in this study: Alternaria tenuis, Phoma betae, Thanatephorus cucumeris (Rhizoctonia solani) and Rhizopus stolonifer. The characteristics of pectolytic enzymes produced by these fungi in vivo and in vitro are described.

MATERIALS AND METHODS.--Rhizoctonia, Alternaria, and Rhizopus, were isolated from sugarbeet crown rot tissue collected at Gilbey, North Dakota. Phoma was isolated from sugarbeet leaf spot material collected at Warren, Minnesota.

The fungi were grown in liquid still cultures at 27°C. The medium consisted of: 1 gm NH₄NO₃, 2.5 gm MgSO₄.7H₂O, 2.5 gm KH₂PO₄, 5.0 gm citrus pectin, 5.0 gm sodium polypectate, and 1 liter distilled water. The pH was adjusted to 5.0. Thirty ml were dispensed per 250 ml culture flask. After autoclaving, the pH was 4.7. Spalding (6) found this medium useful for the production of pectolytic enzymes by R. stolonifer.

Fungal mycelia were removed from culture by filtration through cheesecloth then centrifugation at 3500 g for 15 minutes. Enzyme analyses were made on the filtrates.

^{1/} In cooperation with the Agricultural Experiment Station, North Dakota State University, Fargo.

In vivo analyses were made on greenhouse grown storage roots. The roots were washed, pared, and cut into slices 3-6 mm thick. They were surfaced disinfested in sodium hypochlorite at pH 4.0 for 3 minutes followed by two washings in sterile distilled water. The slices were supported on glass rods in petri dishes containing water saturated filter paper. The slices were inoculated with agar plugs 3 mm in diameter taken from the edge of a fungal colony. After 10 days incubation at 27°C, infected root tissue was blended for 2 minutes in 0.5 N NaCl, filtered and the filtrate was centrifuged for 15 minutes at 3500 g. The filtrate was dialyzed against 100-175 volumes of double glass distilled water for 17-22 hours at 5°C. The dialyzed enzyme was used immediately or stored at -20°C for not more than 2 days.

Pectin methyl esterase (PME) was determined using the continuous titration procedure. Five ml of culture filtrate or dialyzed extract from infected or healthy root tissue were added to 30 ml of 1.5% citrus pectin at pH 5.5. Enzymes boiled for 30 minutes were used as checks. The reaction was carried out at 30°C for 30 minutes. The pH of the mixture was continuously adjusted to pH 5.5 with .01 N NaOH.

A semi-micro (1) thiobarbituric acid (TBA) test was used to identify lyase and polygalacturonase (PG) activity. The reaction mixture consisted of 5 ml of 1% sodium polypectate or citrus pectin buffered at pH 4.5 with .1M acetate or pH 8.5 with .05M Tris-HCl; 1 ml of distilled water or 0.01 M CaCl₂; and 4 ml of culture filtrate or dialyzed enzyme preparation. The mixture was incubated at 30°C for 4 hours. After incubation the reaction mixture was placed in 15 ml centrifuge tubes and 0.6 ml of 9% ZnSO₄·9H₂O and 0.6 ml of 0.5 N NaOH was added to precipitate protein and excess substrate. The mixture was centrifuged at 3500 g for 15 minutes. To 5 ml of this mixture was added 3 ml of 0.04 M TBA, 1.5 ml 1 N HCl and 0.5 ml distilled water. This was boiled in a water bath for 30 minutes. The product was cooled and scanned from 485 to 560 mu on a double-beam spectrophotometer. Galacturonic acid is produced by PG activity on pectin. This combines with TBA to form an amber color. It peaks at 510 mu. Unsaturated galacturonic acid formed from lyase activity is thought to change to formylpyruvate before combining with TBA. This gives a red color and peaks at 547-550 mu.

Viscosimetric determinations were made in No. 300 Fenske-Ostwald viscometers at 30°C. The reaction mixtures contained: 5 ml of 1% NaPP or pectin buffered at pH 4.5 or 8.5, 0.3 ml of distilled water or 0.005 CaCl₂ and 1 ml of culture filtrate or dialyzed enzyme. Viscosimetric units (VU) are defined as the reciprocal X 100 of time to reduce viscosity by one-half.

The strength of storage tissue after exposure to macerating enzymes was measured on a penetrometer as described by Sherwood (5). Tissue slices 0.25 mm thick and 9 mm in diameter were placed in a mixture containing 10 ml of 0.1 M acetate buffer at pH 3.5, 4.5, 5.5 or 10 ml of 0.05 M Tris-HCl buffer at pH 7.5 or 8.5 plus 5 ml of culture filtrate. The mixtures with tissue slices were incubated at 30°C for 1 hour. The force required to burst the slices on the penetrometer were expressed as grams of water converted to log of grams.

Enzyme preparations that had been boiled for 30 minutes were used as controls.

RESULTS.--IN VITRO - PH. The pH of culture filtrates at 5 day intervals during 15 days incubation are shown in Table 1. Alternaria and Phoma caused the pH to rise from the starting pH of 4.7. Although the rate of increase by Phoma was slower than Alternaria at first, the 15 day readings were identical at pH 6.5. Rhizoctonia caused a pH drop followed by a rise to pH 4.2-4.4. The pH in the Rhizopus culture remained unchanged.

TBA TESTS.--Spectral peaks of culture filtrates showed lyase activity by Alternaria, Phoma, and Rhizoctonia but not Rhizopus. Pectin was the favored substrate at pH 8.5.

Pectate lyase also was detectable in all except Rhizopus. This was indicated by peaks at 550 mμ with NaPP as the substrate at pH 8.5.

Peaks at 510 mμ showed that all fungi produced PG when NaPP was the substrate at pH 4.5.

Sherwood (5) has shown that lyase and PG activity could be detected in mixtures if tested on pectin and NaPP at acid and alkaline pH. My results confirm this.

VISCOSIMETRY.--The results in Table 2 are averages of three viscosimetry tests and show quantitative determinations of the pectolytic enzymes present in culture filtrates of different ages. Enzyme activity increased with age for all fungi except Rhizopus. Rhizopus produced polymethylgalacturonase (PMG) and PG whose activity was highest in 5-day-old cultures then declined with age.

PG was produced by all fungi. The greatest amounts were produced by Alternaria and Rhizopus. Rhizoctonia produced more than Phoma.

Pectin lyase was produced in the largest amounts by Alternaria followed by Phoma which produced slightly more than Rhizoctonia at 15 days. No lyase was produced by Rhizopus.

TISSUE MACERATION.--Storage root slices were placed in enzymes from 5, 10 and 15-day-old cultures. The pH was buffered at 3.5, 4.5, 5.5, 7.5 and 8.5. The test was repeated and the results averaged.

Tissue maceration by Rhizoctonia was so slight that conclusions as to an optimum pH or age could not be made.

Although viscosity measurements indicated that pectolytic enzyme activity in Rhizopus decreased with age, penetrometer measurements showed maximum maceration in 10-day-old filtrates at pH 4.5. It is possible that other enzymes in addition to pectolytic enzymes could be involved in maceration.

The macerating activity of Phoma was most extensive in 15-day-old filtrates at pH 7.5.

The macerating activity of Alternaria was most extensive in 10-day-old filtrates at pH 3.5.

Figure 1 shows the 15 day data. Alternaria and Rhizopus were most active at the lower pH and Phoma at a higher pH. Boiled enzyme checks had an average value of 2.41.

IN VIVO TESTS - TBA.--Figure 2 shows spectral curves of TBA reaction products with enzymes extracted from diseased tissue. These peaks are similar to those from culture filtrates. Lyase was produced in infected tissue by Alternaria, Phoma and Rhizoctonia but not Rhizopus. PG was produced by all fungi as indicated by peaks at 510 mu.

Bateman (2) and Ayers, et al. (1) have shown the inhibitory action of Ca^{++} on PG and the stimulatory action on lyase. Figure 3 shows the influence of Ca^{++} on lyase and PG produced by Alternaria in sugarbeet storage roots. The substrate is NaPP. Ca^{++} stimulated pectate lyase by .18 absorption units but decreased PG activity by about .1 absorption unit. The inhibitory action of Ca^{++} on PG activity plays a part in restricting the advance of Rhizoctonia solani through host tissue (2). This might also be true for Alternaria.

VISCOSIMETRY.--Rhizopus produced large amounts of PG as indicated by the reduction in viscosity (Table 3).

The amount was more than 3 times greater than any other fungus in this test. There also was 3 times more polymethylgalacturonase produced by Rhizopus than any other fungus. But as the TBA test indicated, there was no lyase activity.

The greatest amount of lyase was pectin lyase produced by Alternaria. Phoma also produced pectin lyase but only one-half as much as that produced by Alternaria. Pectin lyase was most active at pH 8.5 for both fungi. The addition of Ca^{++} to the reaction mixture reduced pectin lyase activity. This agrees with what Sherwood (5) found with Pellicularia filamentosa f. solani. (Rhizoctonia solani).

The TBA test indicated that Rhizoctonia produced less pectin lyase than Alternaria or Phoma. But the viscosimetry test indicated very little activity by Rhizoctonia on both pectin and NaPP substrates. The viscosity tests were run for one hour, thus the viscosimetric units were expressed as ≤ 1.67 . This indicates that viscosity had not been reduced by one-half during one hour reaction time. The addition of Ca^{++} to the reaction mixture did not stimulate activity as might be expected if pectate lyase were present.

PME.--Filtrates from 5, 10, and 15-day-old cultures and dialyzed extracts from infected or healthy sugarbeet tissue were tested for PME activity. PME was not detected in any of these preparations.

DISCUSSION.--The failure to detect PME in this test does not agree with certain workers. PME has been detected in culture filtrates and in tissues infected with R. solani (1) and R. stolonifer (7). However, Cappellini (3) could not demonstrate PME in culture filtrates of R. stolonifer when grown on a synthetic medium with pectin as the carbon source. I repeated PME tests on enzyme preparations from in vitro and in vivo with negative results. This is important with respect to lyase identification from R. solani. Sherwood has characterized the lyase as pectin lyase (5). But Ayers, et al. (1) suggest that if PME is present, pectin could be demethylated and then become degraded by pectate lyase instead of pectin lyase. They state this can not be resolved until a reaction mixture is known to be free of PME. My results would tend to support those of Sherwood since I was not able to demonstrate PME. Furthermore, if pectate lyase were present, greater activity would be expected to occur on NaPP than on pectin at pH 8.5. This did not occur, rather the greater activity was on pectin.

The spectra of TBA products with enzymes of Rhizoctonia showed PG and lyase activity. Viscosity tests showed PG activity comparable to Rhizopus or Alternaria and more than Phoma. But enzymes produced in culture had very little macerating activity on tissue slices. Extracts from infected storage root slices also demonstrated little activity on pectin or NaPP in the viscosity tests. This particular crown rot isolate of Rhizoctonia may have lost virulence in culture. Or perhaps storage tissue is more resistant than crown tissue to decay by crown rot isolates.

The presence of Ca^{++} stimulated both pectin and pectate lyase activity according to the TBA tests. But viscosimetry tests on enzymes produced in vivo indicated very little pectate lyase and the activity was not affected by Ca^{++} . Pectin lyase activity was inhibited by Ca^{++} . The discrepancy between TBA and viscosimetry in this area, needs further investigation.

Host tissue, of course, is not infected by one pathogen at a time. Rhizoctonia has been isolated from crown rot tissue together with Alternaria (most prevalent) and Rhizopus. Phoma is present in the leaf spot phase throughout the Red River Valley and most likely takes part in storage rot (4). Under natural conditions, Rhizoctonia infects crown tissue followed by Alternaria and Rhizopus. The data presented here showed that Rhizopus produced great amounts of PG and Alternaria produced pectin lyase. This suggests that both enzyme systems, working together, would be more effective in macerating tissue than either enzyme alone. The growth of Alternaria raised the pH of culture media. If this happens in storage root tissue, pectolytic enzyme activity favored by an alkaline pH could be continued by Phoma. Studies on mixed culture infections that might reveal synergism should give us a better understanding of the mechanisms of storage rot.

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Table 1. The pH of culture filtrates during 15 days incubation.

	Age, days		
	5	10	15
Alternaria	4.8	6.2	6.5
Phoma	4.5	4.9	6.5
Rhizoctonia	3.9	4.4	4.2
Rhizopus	4.6	4.7	4.7

Table 2. The effect of pH and age on the activity of culture filtrates on pectin or sodium polypectate (Na PP).

	pH	Viscosity units ^{1/}					
		Pectin			Na PP		
		Age, days			Age, days		
		5	10	15	5	10	15
Alternaria	4.5	29	54	71	82	58	143
	8.5	4	17	26	0	0	0
Phoma	4.5	2	3	1	4	6	3
	8.5	0	3	7	0	0	0
Rhizoctonia	4.5	4	9	15	18	20	40
	8.5	3	2	3	0	0	0
Rhizopus	4.5	32	20	16	138	22	21
	8.5	0	0	0	0	0	0

^{1/} Viscosity units = reciprocal multiplied by 100 of time in minutes to reduce viscosity by one half.

Table 3. Pectolytic enzyme activity of extracts of sugar beet storage roots infected with four storage rot fungi.

	pH	Viscosity units ^{1/}	
		Pectin	Na PP
Alternaria	4.5	1.56	3.70
	8.5	6.35	2.50
Phoma	4.5	<1.67 ^{2/}	4.35
	8.5	3.45	<1.67
Rhizoctonia	4.5	<1.67	<1.67
	8.5	<1.67	<1.67
Rhizopus	4.5	5.06	15.38
	8.5	<1.67	8.33

^{1/} Viscosity units = reciprocal multiplied by 100 of time in minutes to reduce viscosity by one half.

^{2/} Reaction times were not run longer than 1 hour.

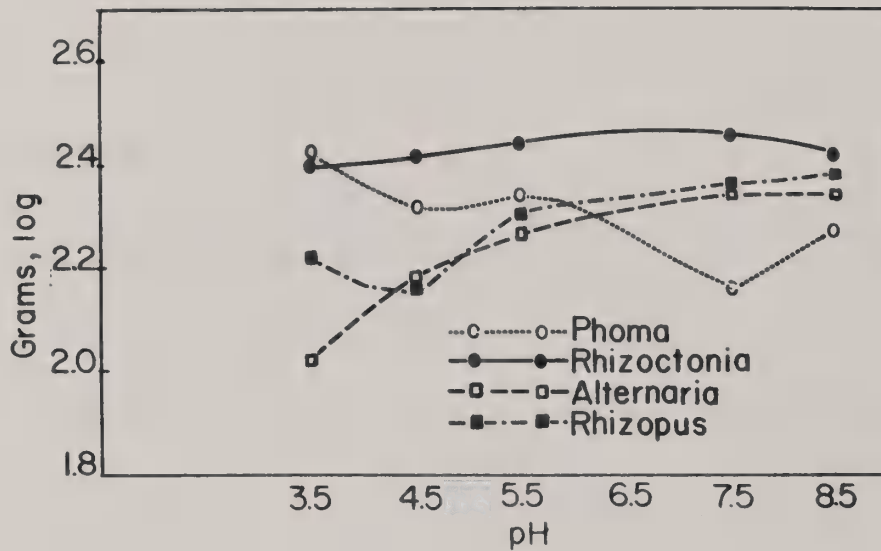


Fig. 1. The effect of pH on macerating activity of enzymes produced by storage rot fungi. Tissue strength expressed as grams of water required to burst tissue.

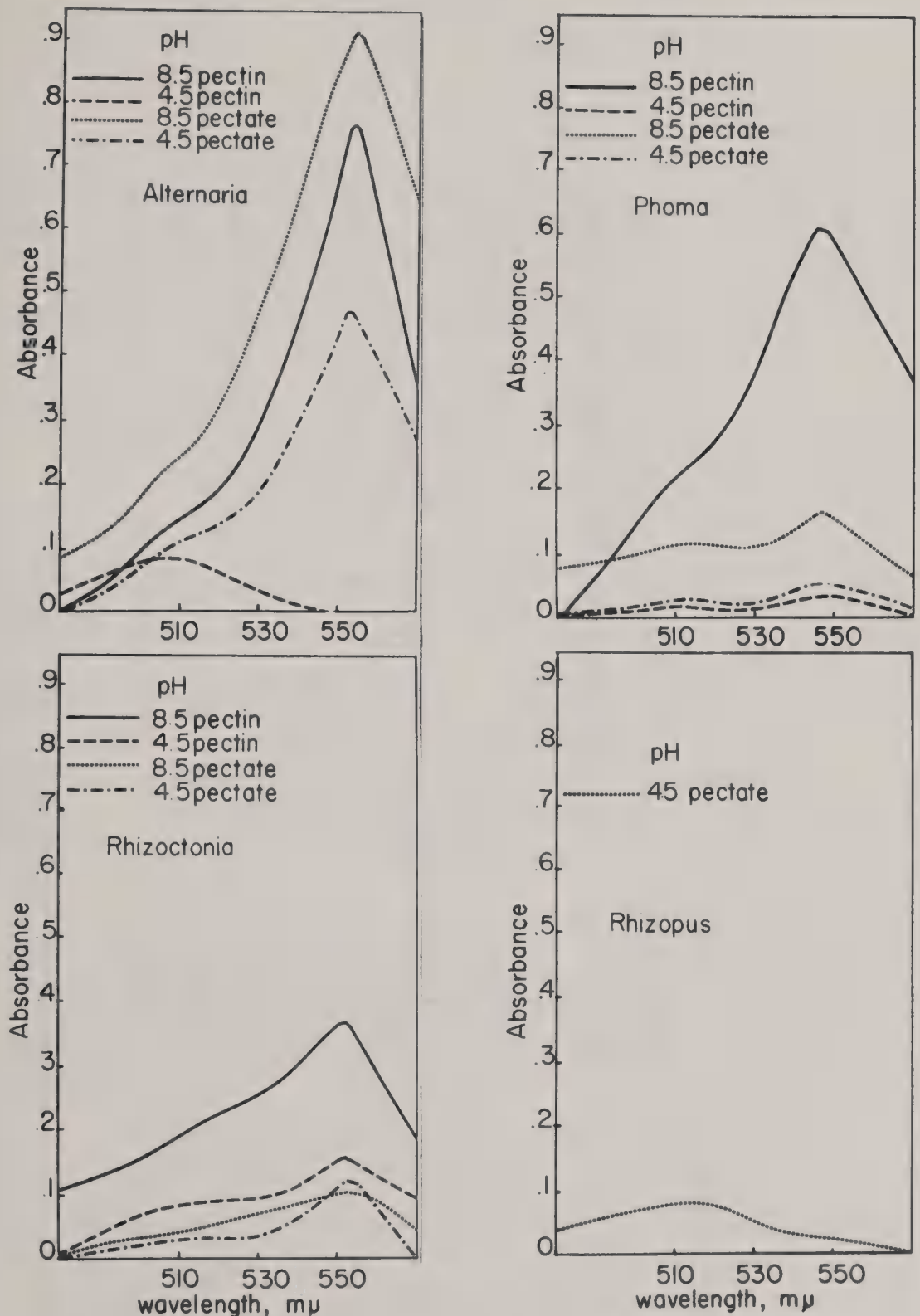


Fig. 2. The effect of pH and substrate on the activity of pectolytic enzymes extracted from infected storage root tissue.

The identification of polygalacturonase and lyase from infected storage root tissue. Peaks at 550 mμ indicate lyase and 510 mμ polygalacturonase.

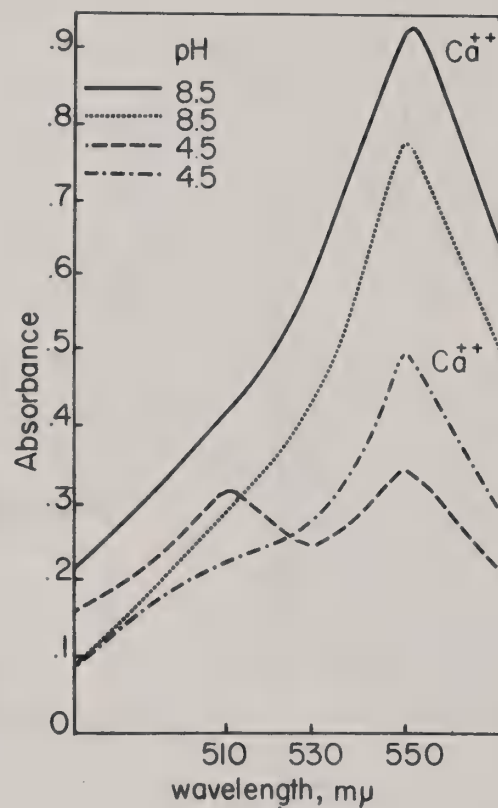


Fig. 3. The effect of Ca^{++} and pH on the activity of pectolytic enzymes produced by Alternaria tenuis in storage root tissue. Substrate is sodium polypectate.

Red River Valley Variety Test - Fargo, N. D. 1970

	Beets T/A	% Sucrose	Impurity index	PPM	
				N	K
Holly 8315-03	17.5 a	14.8 abc	1203	772	2205
Holly HH-10	17.1 a	14.9 abc	1120	780	2418
Holly HH-19	17.0 a	14.6 bc	1040	628	2430
Am. 3A	16.4 ab	14.1 c	1264	827	2288
Am. 2B	16.2 abc	14.1 c	1035	782	2075
Holly 9320-06	15.6 abcd	14.4 bc	1121	788	2285
Am. 3N	15.1 abcde	13.8 c	1444	1124	2110
Betaseed B-93	13.9 bcde	15.5 ab	1084	815	2450
U. S. 401	13.4 bcde	14.0 c	1193	744	2355
Betaseed B-96	13.3 bcde	15.0 abc	1227	810	2785
Am. 67-403	13.3 cde	14.7 bc	1096	818	2205
Am. 3T	13.2 cde	15.8 a	1020	801	2395
Betaseed B-951	12.4 def	15.4 ab	1064	794	2282
FC-702	12.2 ef	14.5 bc	1182	794	2518
FC-702/2	12.2 ef	14.8 abc	1086	755	2428
FC-701	9.2 f	14.1 c	1300	945	2295
FC-701/2	9.1 f	14.0 c	1463	1088	2260

Red River Valley Variety Test - Fargo, N. D. 1970 (Cont.)

Fertilizer application 5-7-70: 300 lb NH_4NO_3
225 lb P_2O_5

Planted: 5-28-70 (third year for sugarbeets)

Harvested: 10-6-70

Design: Complete randomized block, 4 replicates

Plot size and sample: 2 row (24") X 20 ft

Sucrose % from one 25 lbs sample/plot

Uniform stand. Very dry from June to harvest.

Diseases: Trace of Alternaria and Phoma

Statistical analysis: Duncan's New Multiple Range on yield roots/A
and % sucrose. 5% level.

